QL
1
.R454
NH

REVUE SUISSE DE ZOOLOGIE

VOLUME
127 (2) – 2020

Swiss Journal of Zoology

Muséum genève

Swiss Zoological Society

VILLE DE GENÈVE

REVUE SUISSE DE ZOOLOGIE
Swiss Journal of Zoology

VOLUME
127 (2) – 2020

La Revue suisse de Zoologie est éditée par le Muséum de la Ville de Genève et la Société suisse de Zoologie. Elle est subventionnée par l'Académie suisse des Sciences naturelles (SCNAT) et la Ville de Genève.

Comité de rédaction / Editorial board

Alice Cibois, Peter Schuchert, Muséum d'histoire naturelle de la Ville de Genève

Rédacteurs adjoints / Associate editors

A. Cibois (Aves), R. Covain (poissons/fish), G. Cuccodoro (Coleoptera), J. Hollier (Arthropoda), B. Landry (Insecta, excl. Coleoptera), J. Mariaux (invertébrés excl. arthropodes/invertebrates excl. arthropods), M. Ruedi (Mammalia), A. Schmitz (Amphibia, Reptilia), P. Schwendinger (Arthropoda excl. Insecta).

Soumission de manuscrits et abonnements / Submission of manuscripts and subscriptions

Revue suisse de Zoologie
Muséum d'histoire naturelle
Case postale 6434
1211 Genève 6
rsz@ville-ge.ch
Internet: http://institutions.ville-geneve.ch/fr/mhn/frontpage/revue-suisse-de-zoologie/

Prix de l'abonnement annuel (2 fascicules) / Annual subscription (2 issues)
Suisse CHF 130.–
Union postale CHF 150.–

Maquette de couverture: Doris Simon, Florence Marteau, Muséum d'histoire naturelle de la Ville de Genève
Composition et mise en page: Corinne Charvet, Muséum d'histoire naturelle de la Ville de Genève
Administration: Muséum d'histoire naturelle de la Ville de Genève
Impression: Centrale municipale d'achats et d'impression de la Ville de Genève

Photo de couverture: *Lycodon pictus*, by Jin-Long Ren, see article p. 413.

ISSN 0035 - 418 X

REVUE SUISSE DE ZOOLOGIE

Swiss Journal of Zoology

VOLUME
127 (2) – 2020

Swiss Zoological Society

REVUE SUISSE DE ZOOLOGIE
Swiss Journal of Zoology

VOLUME
127 (2) – 2020

Li W., Qi L. & Yang D. - First Chinese record and the second species of the genus *Pleurigona* Malloch, 1929 (Diptera: Lauxaniidae)..... 245-248

Gilgado J.D. - Hidden in plain sight: six millipede species (Myriapoda: Diplopoda) new for the fauna of Switzerland 249-259

Draghi R., Drago F.B., Saibene P.E. & Agostini M.G. - Helminth communities from amphibians inhabiting agroecosystems in the Pampean Region (Argentina) 261-274

Logunov D.V. & Ponomarev A. - *Karakumosa* gen. nov., a new Central Asian genus of fossorial wolf spiders (Araneae: Lycosidae: Lycosinae) 275-313

Sartori M. & Bauernfeind E. - Mayfly types and additional material (Insecta: Ephemeroptera) examined by F.-J. Pictet and A.-E. Pictet, housed in the Museums of Natural History of Geneva and Vienna..... 315-339

Hollier J., Marshall J. & Legendre F. - An annotated list of the Blattodea (Insecta) described by Henri de Saussure. Part 1: the Corydiidae 341-348

Tanasevitch A.V. - Linyphiid spiders collected by V. Mahnert in Kenya, with the description of a new genus and two new species (Arachnida: Araneae) 349-360

Yin Z.-W. & He L. - A new species of *Diartiger* Sharp from Sichuan, China (Coleoptera: Staphylinidae Pselaphinae) 361-366

Galea H.R. - *Plumularia roxanae,* a new epiphytic hydroid (Cnidaria: Hydrozoa:Plumulariidae) from the Indo-Pacific 367-376

Yin Z.-W. & Kleeberg A. - Description of *Cerochusa gesinae* sp. nov. from Thailand (Coleoptera: Staphylinidae: Pselaphinae) 377-380

Martens J. - A mysterious dwarf: Suthepiidae nov. fam., a new harvestman family from mountains of northern Thailand (Arachnida: Opiliones: Laniatores)..... 381-391

Lorenzo D., Ricarte A., Nedeljković Z., Nieves-Aldrey J.L. & Marcos-García M.A. - Hoverflies (Diptera: Syrphidae) of E Ventorrillo Biological Station, Madrid province, Spain: a perspective from a late twentieth century inventory 393-412

Janssen H.Y., Jin-Long R., Jia-Tang L., Zeng W., Nguyen T.T., Nguyen T.Q., Bui Q.T.T., Ngo H.T., Le M.D. & Ziegler T. - Range extension and extended diagnosis of *Lycodon pictus*: First country record from China 413-422

Schwendinger P.J., Lehmann-Graber C., Hongpadharakiree K. & Syuhadah N. - New euagrid spider species fom Thailand and Malaysia, and new localities of *Leptothele bencha* (Arachnida: Araneae)..... 423-453

Revue suisse de Zoologie (September 2020) 127(2): 245-248 ISSN 0035-418

First Chinese record and the second species of the genus *Pleurigona* Malloch, 1929 (Diptera: Lauxaniidae)

Wenliang Li[1, *], Ling Qi[1] & Ding Yang[2]

[1] *College of Forestry, Henan University of Science and Technology, Luoyang 471023, China*
[2] *Department of Entomology, China Agricultural University, Beijing 100193, China*
[#] *Corresponding author: laughonce@126.com; wenliangli@haust.edu.cn*

Abstract: The genus *Pleurigona* Malloch, 1929 is newly recorded in China with the description of one new species, *Pleurigona bicolor* sp. nov. Photographs and illustrations are provided for the species.

Keywords: Lauxaniidae - *Pleurigona* - first record - new species - China.

INTRODUCTION

The genus *Pleurigona* Malloch, 1929 (Diptera: Lauxaniidae) was introduced for *P. curvinervis* Malloch, 1929 from Luzon, Philippines. This genus can be recognized by the following characteristics: face convex; frons bare, strongly inclined and on the same plane with the face; the thorax is pronouncedly arched, with strong dorsocentrals and acrostichals; the preapical ad of fore and hind tibiae quite long, the preapical ad mid tibia short; the vein R1 sinuous and roundly curved forward at apex; M1 conspicuously arched down to wing margin. The genus *Pleurigona* Malloch, 1929 is here newly recorded from China with the description of *Pleurigona bicolor* sp. nov. With this new species, the genus now contains two species, distributed in the Oriental Region.

MATERIAL AND METHODS

Genitalia preparations were made by removing and macerating the apical portion of the abdomen in cold saturated NaOH for 6 hours. After examination, they were transferred to fresh glycerine and stored in a microvial on the pin below the specimen or moved to an ethanol tube together with the wet specimens. The examined specimens have been deposited in the Entomological Museum of China Agricultural University (CAU), Beijing.

The general terminology follows Gaimari & Silva (2010). According to Shi & Yang (2014), the "protandrium" in the previous paper are replaced with "syntergosternite". The following abbreviations are used: *a* – anterior seta, *acr* – acrostichal seta, *ad* – anterior dorsal seta, *anepst* – anepisternal seta, *app* – apical posterior seta, *apv* – apical ventral seta, *av* – anterior ventral seta, CuA_1 – cubital vein, cua_1 – anterior cubital cell, *dc* – dorsocentral seta, *dp* – dorsal preapical seta, *kepst* – katepisternal seta, M – medial vein, *oc* – ocellar seta, *or* – fronto-orbital seta, *pd* – posterior dorsal seta, *prsc* – prescutellar seta, *pv* – posterior ventral seta, R – radial vein, r – radial cell, $2m_2$ – apical fifth radial cell.

TAXONOMIC PART

Pleurigona bicolor sp. nov.

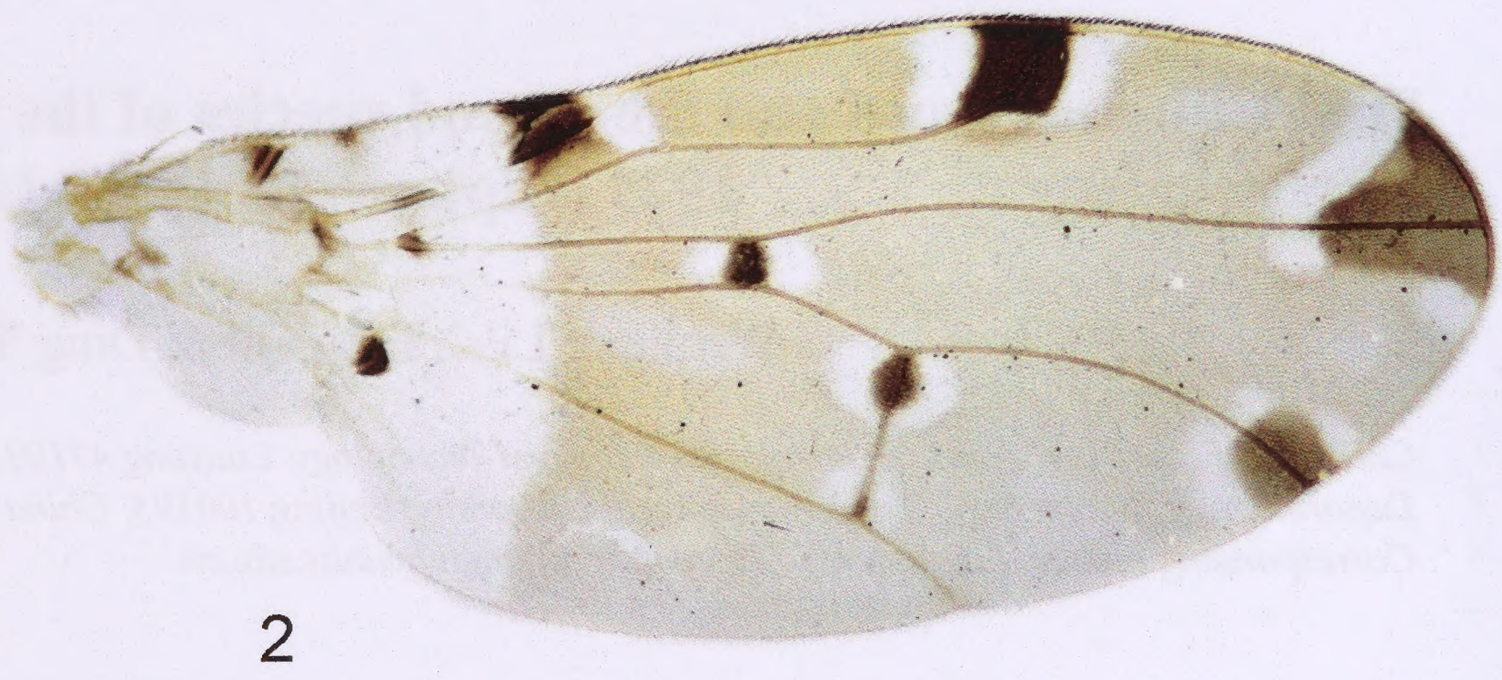
Figs 1-10

Type material: Holotype, male; CHINA, Guizhou Province, Suiyang, Kuankuoshui reserve, Zhongxinzhan, 28.2076°N 107.1726°E, 1449 m; collected 15.08.2010; collector Guoquan Wang (CAU). – Paratypes, 1 male, 1 female; otherwise same data as holotype (CAU).

Diagnosis: Head (Fig. 1) pale yellow, with brown lateral band; face slightly convex; frons inclined strongly, face and anterior mesoscutum on same plane. Mesoscutum (Fig. 4) with 1 pair of wide brown lateral bands, 1 wide brown median band composed of 5-6 brown oval spots which get brighter from poasterior to anterior; wing (Fig. 2) with basal third hyaline, with some brown spots at cross points of veins; costal cell R_{2+3}, R_{4+5}, M_1 each with 1 square apical spot, except apical spot of R_{4+5} nearly flabelliform; a brown spot

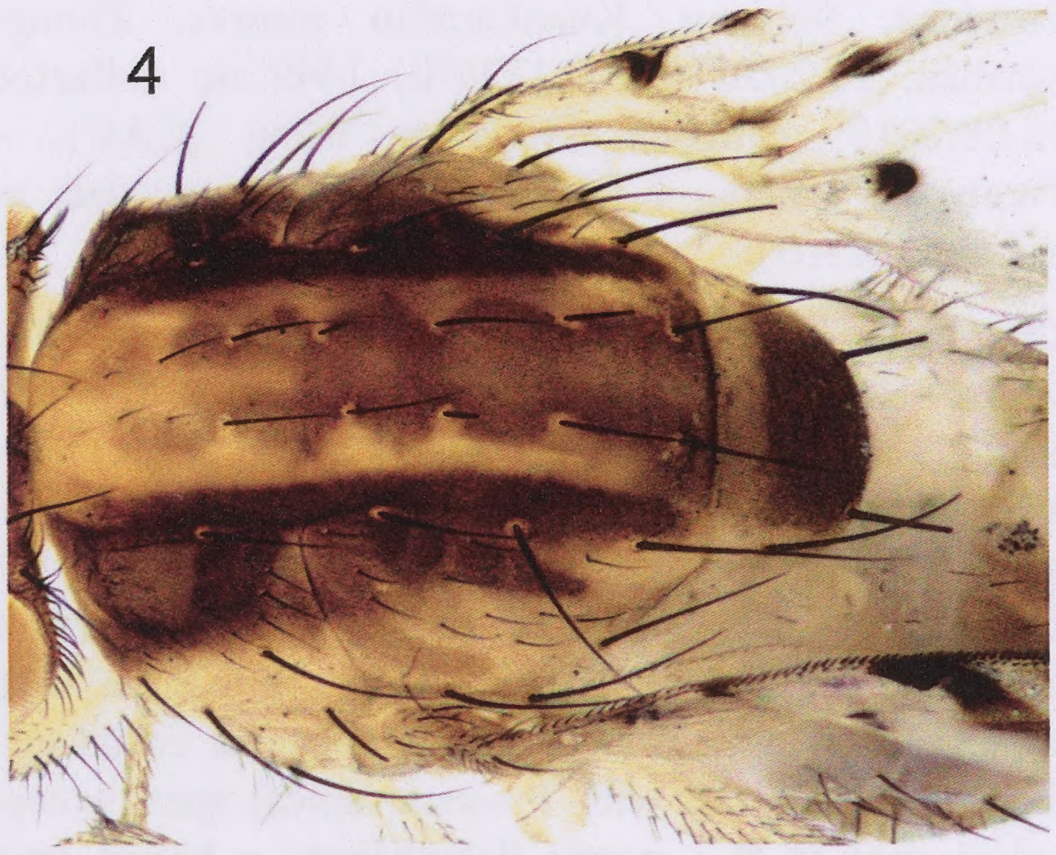
Manuscript accepted 12.03.2020
DOI: 10.35929/RSZ.0018

1



2

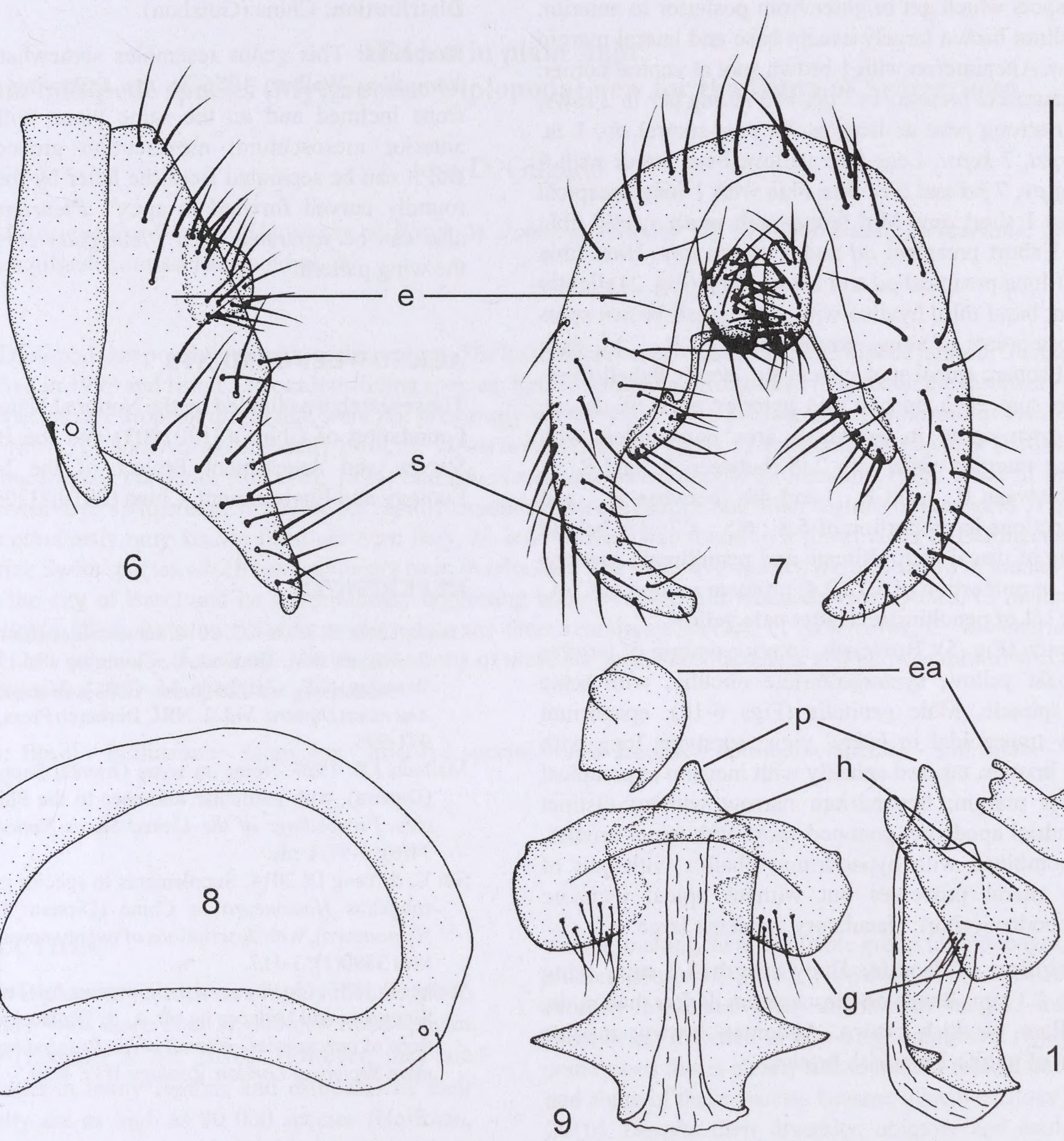
3



4

5

Figs 1-5. *Pleurigona bicolor* sp. nov. Male. (1) Body, lateral view. (2) Wing. (3) Head, dorsal view. (4) Mesoscutum, dorsal view. (5) Abdomen, dorsal view.



Figs 6-10. *Pleurigona bicolor* sp. nov. Male. (6) Protandrium and epandrium, lateral view. (7) Epandrial complex, posterior view. (8) Protandrium, anterior view. (9) Phallic complex, ventral view. (10) Phallic complex, lateral view. Scale 0.5 mm. e: epandrium; s: surstylus; ea: ejaculatory apodeme; p: phallapodeme; h: hypandrium; g: gonopod.

each on r-m and anterior apex of *dm-cu*; all brown spots on brownish area surrounded with hyaline margin. Abdomen (Fig. 5) brownish; anterior margin of tergites 1-2 pale yellow.

Etymology: Latin, *bicolor*, meaning bicolour, referring to wing hyaline basally and brown apically.

Description of male: Body length 3.3-3.5 mm, wing length 4.3-4.5 mm.

Head (Fig. 1): Pale yellow, with brown lateral band, covering frons partly above eye, gena, ventral corner of face, and lateral clypeus below eye. Face slightly convex. Frons yellow, about as long as wide and parallel-sided, inclined strongly, with face and anterior mesoscutum on same plane. Ocellar triangle yellow; *oc* strong, longer than posterior *or*, anterior *or* reclinated and shorter than posterior *or*. Gena about 1/3 height of eye. Antenna yellowish, 1st flagellomere 1.4 times longer than high; arista short pubescent, brown except yellow base, with longest hairs as long as 1/2 width of 1st flagellomere. Proboscis yellowish with margin black partly, with yellowish and blackish hairs; palpus pale yellow with black hairs.

Thorax (Fig. 4): Yellow with grayish white pruinescence. Mesoscutum with 1 pair of wide brown lateral bands, 1 wide brown median band composed of 5-6 brown

oval spots which get brighter from posterior to anterior. Scutellum brown largely except base and lateral margin yellow. Anepimeron with 1 brown spot at ventral corner. Propleuroseta present, 1+3 *dc*, 1+3 strong *acr* in 2 rows, 1 pair strong *prsc* as long as 1st post-sutural *dc*, 1 *ia*, 1 *anepst*, 2 *kepst*. Legs pale yellow. Fore femur with 6 strong *pv*, 7 *pd* and 5 *p*; fore tibia with 1 long preapical *ad* and 1 short *apv*. Mid femur with weak *a*; mid tibia with 1 short preapical *ad* and 1 strong *apv*. Hind tibia with 1 long preapical *ad* and 2 *apv*. Wing (Fig. 2) slightly brown, basal third hyaline with some small brown spots at cross points of veins; costal cell, R_{2+3}, R_{4+5}, M_1 each with 1 square apical spot, except R_{4+5} nearly flabelliform; brown spot each on r-m and anterior apex of *dm-cu*; all brown spots in brownish area surrounded with hyaline margin; costa with 2nd (between R_1 and R_{2+3}), 3rd (between R_{2+3} and R_{4+5}) and 4th (between R_{4+5} and M_1) sections in proportion of 5.8 : 6.5 : 4.2; *r-m* behind middle of discal cell; ultimate and penultimate sections of M_1 in proportion of 5.7 : 2.4; ultimate section of CuA_1 about 1/4 of penultimate. Halter pale yellow.

Abdomen (Fig. 5): Brownish, anterior margin of tergites 1-2 pale yellow, syntergosternite circular, with setae near spiracle. Male genitalia (Figs 6-10): epandrium nearly trapezoidal in lateral view; surstylus long with many bristles, tapered apically with incision at preapical anterior margin; hypandrium narrow without distinct hypandrial apodeme; gonopod short with many bristles, and combined with hypandrium; phallus with pair of acute lateral processes but without apical incision; phallapodeme short; ejaculatory apodeme large.

Description of female: Body length 3.3 mm, wing length 4.3 mm. Bands on mesoscutum darker than male; scutellum blackish brown. Abdomen brown; median region of tergite 2 blackish brown.

Distribution: China (Guizhou).

Remarks: This genus resembles somewhat the genus *Xangelina* Walker, 1856 in the following characters: frons inclined and on the same plane with face and anterior mesoscutum; mesoscutum arched strongly. But it can be separated from the latter by the trait "R_{2+3} roundly curved forward at apex". *Pleurigona bicolor* also can be separated from *Pleurigona curvinervis* by the wing pattern.

ACKNOWLEDGEMENTS

The research was funded by the National Natural Science Foundation of China (31301903) and the Biodiversity Survey and Assessment Project of the Ministry of Ecology and Environment, China (2019HJ2096001006).

REFERENCES

Gaimari S.D. & Silva V.C. 2010. Lauxaniidae (Lauxaniid flies). *In*: Brown B.V., Borkent A., Cumming J.M., Wood D.M., Woodley N.E., Zumbado M. (Eds.), *Manual of Central American Diptera.* Vol. 2. NRC Research Press, Ottawa, pp. 971-995.

Malloch J.R. 1929. Notes on some Oriental Sapromyzid flies (Diptera), with particular reference to the Philippine species. *Proceedings of the United States National Museum* 74(6): 1-97, 6 pls.

Shi L. & Yang D. 2014. Supplements to species groups of the subgenus *Homoneura* in China (Diptera: Lauxaniidae: *Homoneura*), with descriptions of twenty new species. *Zootaxa* 3890(1): 1-117.

Walker F. 1856. Catalogue of the dipterous insects collected at Singapore and Malacca by Mr. A. R. Wallace, with descriptions of new species. *Journal of the Proceedings of the Linnean Society of London. Zoology* 1(1): 4-39.

Revue suisse de Zoologie (September 2020) 127(2): 249-259 ISSN 0035-418

Hidden in plain sight: six millipede species (Myriapoda: Diplopoda) new for the fauna of Switzerland

José D. Gilgado

Section of Conservation Biology, University of Basel, St. Johanns-Vorstadt 10, CH-4056 Basel, Switzerland. E-mail: josedomingo.gilgadohormaechea@unibas.ch

Abstract: Diplopoda are poorly studied in many regions. The last comprehensive work on the millipede fauna of Switzerland was published in 1993 and listed 124 outdoor-living species. Recent sampling efforts have resulted in the discovery of six millipede species of European origin that were not previously known to occur in Switzerland: *Cylindroiulus britannicus* (Verhoeff, 1891), *C. salicivorus* Verhoeff, 1908, *C. vulnerarius* (Berlese, 1888), *Heteroiulus intermedius* (Brölemann, 1892), *Anamastigona pulchella* (Silvestri, 1894) and *Macrosternodesmus palicola* Brölemann, 1908. None of them is currently invasive in Switzerland, but some are rapidly expanding across Europe and other regions of the world. A species which was previously only known from northern Italy, *H. intermedius*, was found in a forest close to Bellinzona. It is likely a native Swiss species which has previously been overlooked. The other five species were collected in human-made habitats in the city of Basel and its surroundings, suggesting human-caused introduction. Two species, *C. britannicus* and *M. palicola*, likely have an Atlantic origin, while the three remaining species, *C. salicivorus*, *C. vulnerarius* and *A. pulchella*, are originally from Italy. The biogeography of these six species is discussed, and photographs of specimens of each species and their gonopods are presented.

Keywords: Basel - Bellinzona - faunistics - invasive species - new records - non-native species - soil fauna - urban biodiversity.

INTRODUCTION

Millipedes (Diplopoda) constitute a highly diverse group of arthropods, with more than 11 000 described species worldwide (Enghoff *et al.,* 2015). However, they are poorly studied in many regions and estimates of their real diversity are as high as 80 000 species (Hoffman, 1980), though caution has been advised considering such estimates (Brewer *et al.,* 2012). Most millipede species are soil dwelling detritivores, feeding mostly on decaying plant material, but some can feed on fungi, faeces, algae, and rarely, dead invertebrates (David, 2015). They play an important role in litter decomposition in temperate forests, consuming up to 15% of the annual leaf fall (Golovatch & Kime, 2009). While millipedes seem to have a low assimilation efficiency, they are important for nitrogen mineralization (Cárcamo *et al.,* 2000; David, 2015). Most millipede species have a relatively low dispersal ability, which results in small distribution ranges and in a high number of endemic and microendemic species (Golovatch & Kime, 2009). Higher taxonomic levels have also limited geographical ranges, making them a suitable group for biogeographical studies (Enghoff, 2015). However, many species have recently expanded their distribution ranges, some of them being recorded in new biogeographical regions. In some cases this is clearly due to human-related transport, and some of these species became invasive (Stoev *et al.,* 2010). Despite their diversity, ubiquity and ecological importance, millipedes are a yet understudied group of arthropods (Brewer *et al.,* 2012).

In Switzerland the most recent comprehensive work on millipede faunistics was written by Pedroli-Christen (1993), who listed 126 millipede taxa (124 species, two of them with two subspecies each) occurring outdoors. While her work is an exhaustive compilation of the known records and a starting point for studying the Swiss millipede fauna, the nomenclature is out of date and a new list including recent synonyms and records is urgently needed. Only the record of one additional millipede species, *Polydesmus rupicursor* Verhoeff, 1907, found in southeastern Switzerland (Bogyó *et al*., 2013), was published since Pedroli-Christen (1993). According to the known distribution of *P. rupicursor* in northern

Manuscript accepted 13.05.2020
DOI: 10.35929/RSZ.0019

Italy (Kime & Enghoff, 2011) it is not clear whether this species recently arrived in Switzerland, or if it is native to the country. The most recent works of A. Pedroli-Christen, R. Hoess and A. Scholl were published in the 1990s and early 2000s (e.g. Pedroli-Christen & Scholl, 1996; Stojalowska & Pedroli-Christen, 1996; Hoess & Scholl, 1999; Hoess, 2000; Hoess & Scholl, 2001). The absence of active diplopodologists in Switzerland since then has resulted in incomplete knowledge of the current species distribution of this group. Specialists working abroad, who received material collected in Switzerland (e.g. Vilisics *et al.,* 2012), partially mitigated this problem. However, much remains unknown. For example, Wittenberg (2005) stated that millipedes are a neglected group for which it is not possible to provide a list of invasive species for Switzerland. He suggested that their number (together with Chilopoda) should not be more than ten species and these species should not be a threat to the native biodiversity and ecosystems. However, in recent times at least one invasive millipede species, *Oxidus gracilis* (Koch, 1847) (Polydesmida, Paradoxosomatidae), caused problems in rural areas of Switzerland because of its swarming behaviour (see Macbeth, 2018). The consequences for local biodiversity from the invasion by this or other non-native millipede species in urban areas, as well as their potential to colonise rural or natural areas are not known. Recent surveys resulted in six new millipede records for Switzerland, which are presented in this paper. Comments on their distribution ranges and their presence in Switzerland are provided, together with photographs of the specimens and their gonopods.

MATERIAL AND METHODS

Most of the specimens examined were collected in two biodiversity surveys focusing on soil-surface-active invertebrates. The first survey was conducted in 26 urban forests and 26 grasslands in the city of Basel and its surroundings in 2014 (see Melliger *et al.,* 2018 for a detailed description of the survey sites). In the second survey invertebrates were sampled in 35 private gardens in Basel and nearby municipalities during summer and autumn 2018. Additional specimens were captured during sporadic millipede sampling in the region of Basel and in the canton of Ticino in the years 2017 and 2018. Three methods were used to sample millipedes: active capture, hay baits and pitfall traps.

The active capture was conducted by visually searching under stones, deadwood and leaf litter, and in the case of the private gardens also under pots and in compost heaps. The active capture in gardens was conducted for 15 min./visit, and each garden was visited twice each in early summer, late summer and autumn (a total of 90 min search per garden). The specimens were collected with forceps and directly put in 70% ethanol.

Pitfall traps had a diameter of 5.8 cm and were filled with 60 ml of saturated brine as preservative. Five pitfall traps were placed in each private garden and operated for 7-day periods in early summer, late summer and autumn each. The traps were protected from rain and animal interference by a roof consisting of a plastic square of 27 x 27 cm. During the 2014 survey, 12 pitfall traps of the same type as in the gardens were set in two parallel rows of 6 traps in forests and grasslands in Basel and its surroundings. Pitfall traps were separated by 5 m. No roofs were used to avoid drawing attention in these publicly accessible locations. Pitfall traps were operated for 7-day periods each in spring, summer and autumn. In forest sites pitfall traps were operated for two additional periods in summer. Five hay baits (Tuf *et al.,* 2015) were placed in each garden in the same periods as the pitfall traps were operating. Hay baits were subsequently transported to the laboratory and individually placed in Berlese funnels for a standard period of 10 days to extract the arthropods. Two hay baits were used in December 2017 and September 2018 in one of the sampling points of the 2014 surveys, an urban forest fragment in Basel. These hay baits were operated for a month and placed in Berlese funnels for 10 days.

Although the gardens were surveyed using three methods, specimens of all six species new for Switzerland were exclusively collected by active capture. Due to privacy reasons the exact coordinates of the private gardens are not given, but a nearby point of the same street instead. Some male specimens were dissected for the study of their gonopods. Examples of all species were determined using a Leica M205 C and photographed using a Keyence VHX-6000 microscope. All specimens examined are deposited in the collection of the Naturhistorisches Museum Basel (NMB, registration numbers given).

TAXONOMIC PART

Order Julida Brandt, 1833
Family Julidae Leach, 1814
Genus *Cylindroiulus* Verhoeff, 1894
Cylindroiulus britannicus (Verhoeff, 1891)

Fig. 1

Iulus britannicus Verhoeff, 1891.

Cylindroiulus pollicaris Attems, 1904.

Cylindroiulus pollinaris. – Attems, 1933 (misspelling of *pollicaris*).

Material examined: NMB-699a; 1 male & 1 female; Switzerland, Basel-Landschaft, Liestal, 47°29'54.47"N, 7°43'59.91"E, 380 m; 10.04.2018; J. D. Gilgado leg.; active capture under stones at the margin of a path in agricultural land. – NMB-699b; 2 males & 1 female; Switzerland, Basel-Landschaft, Binningen, private garden, 47°32′33.03″N, 7°34′16.22″E, 315 m; 12.06.2018; J. D. Gilgado *et al.* leg.; active capture. – NMB-699c; 1 male; same data but 17.10.2018. –

NMB-699d; 1 male; Switzerland, Basel-Landschaft, Binningen, private garden, 47°32′27.19″N, 7°33′23.18″E, 325 m; 26.07.2018; J. D. Gilgado *et al.* leg.; active capture. – NMB-699e; 1 male; same data but 16.10.2018. – NMB-699f; 1 male; Switzerland, Basel-Stadt, 47°31′33.86″N, 7°35′26.82″E, 360 m; 09.08.2018; J. D. Gilgado *et al.* leg.; active capture. – NMB-699g; 1 male, 4 females & 1 juvenile; same data but 26.09.2018. – NMB-699h; 2 males & 1 female; same data but 03.10.2018.

Distribution: In Europe this species is known from Austria, the British Isles, the Czech Republic, Denmark, Finland, France, Germany, Lithuania, the Netherlands, Norway, Poland, Portugal (mainland, Azores and Madeira Islands), Romania, Russia (Central European Russia and north-western Russia), Spain (mainland and Canary Islands), Sweden and Ukraine. It has been introduced to Africa, Australia, North and South America and the Oriental region (Kime & Enghoff, 2017).

Remarks: This species is commonly found associated with decomposing deadwood, but also in soils close to deadwood and in leaf litter. The species may have a Lusitanian or Atlantic origin as it is a very common species in the British Isles, but it is nowadays a synanthropic cosmopolitan species (Kime & Enghoff, 2017).

Cylindroiulus salicivorus Verhoeff, 1908

Fig. 2

Cylindroiulus salicivorus Verhoeff, 1908.
Castaneoiulus salicivorus. – Verhoeff, 1930.

Material examined: NMB-700a; 1 male; Switzerland, Basel-Stadt, private garden, 47°34′01.05″N, 7°34′41.16″E, 260 m; 31.05.2018; J. D. Gilgado *et al.* leg.; active capture. – NMB-700b; 1 female; Switzerland, Basel-Landschaft, Binningen, private garden, 47°32′11.68″N, 7°33′49.24″E, 345 m; 20.06.2018; J. D. Gilgado *et al.* leg.; active capture.

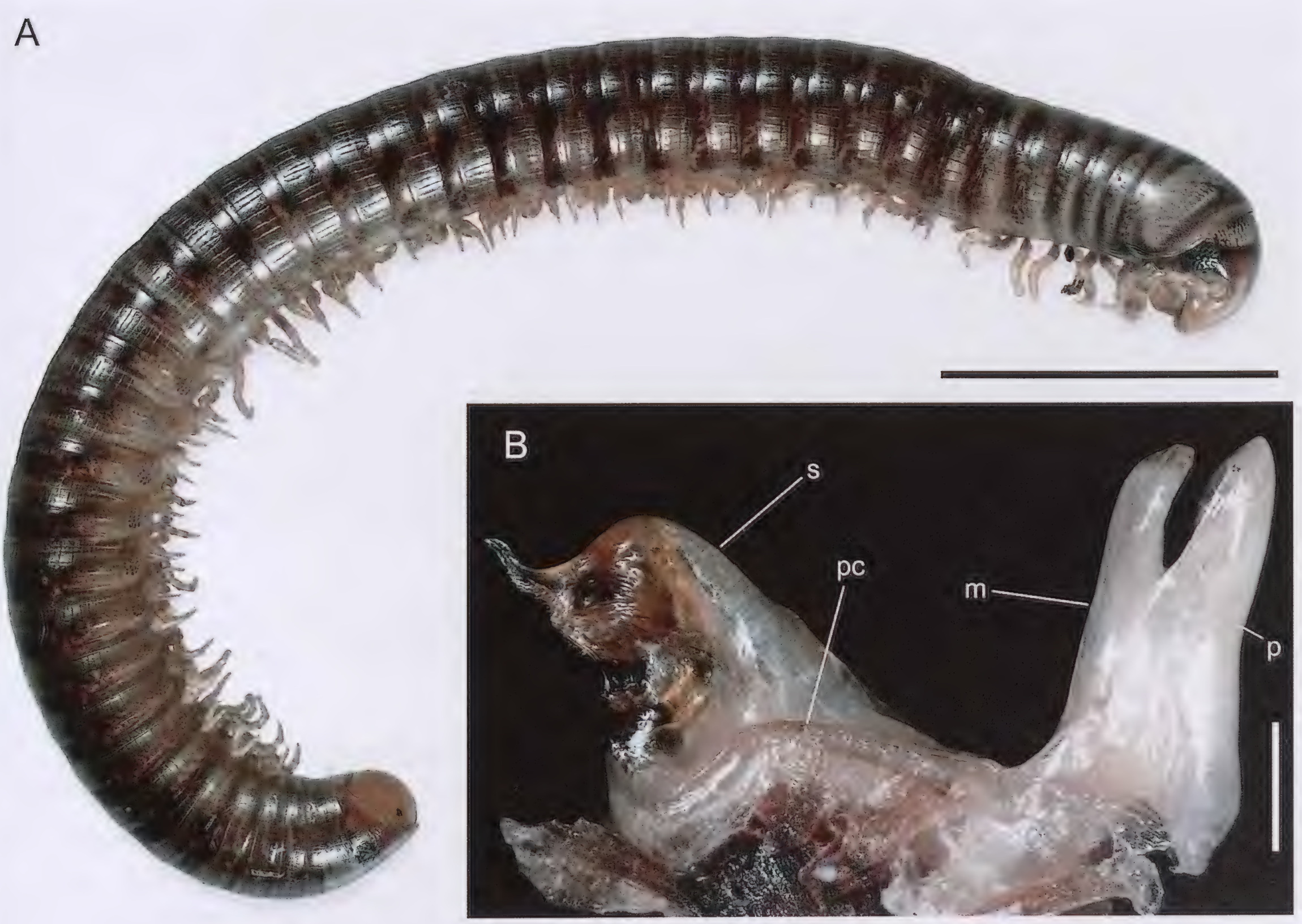


Fig. 1. *Cylindroiulus britannicus* (Verhoeff, 1891). (A) Dissected adult male from Basel-Stadt (NMB-699g). Scale bar 2 mm. (B) Gonopod of specimen from Liestal (NMB-699a) in lateral view. Scale bar 0.1 mm. Abbreviations: m, mesomerite; p, promerite; pc, lateral rim of paracoxite; s, solenomerite.

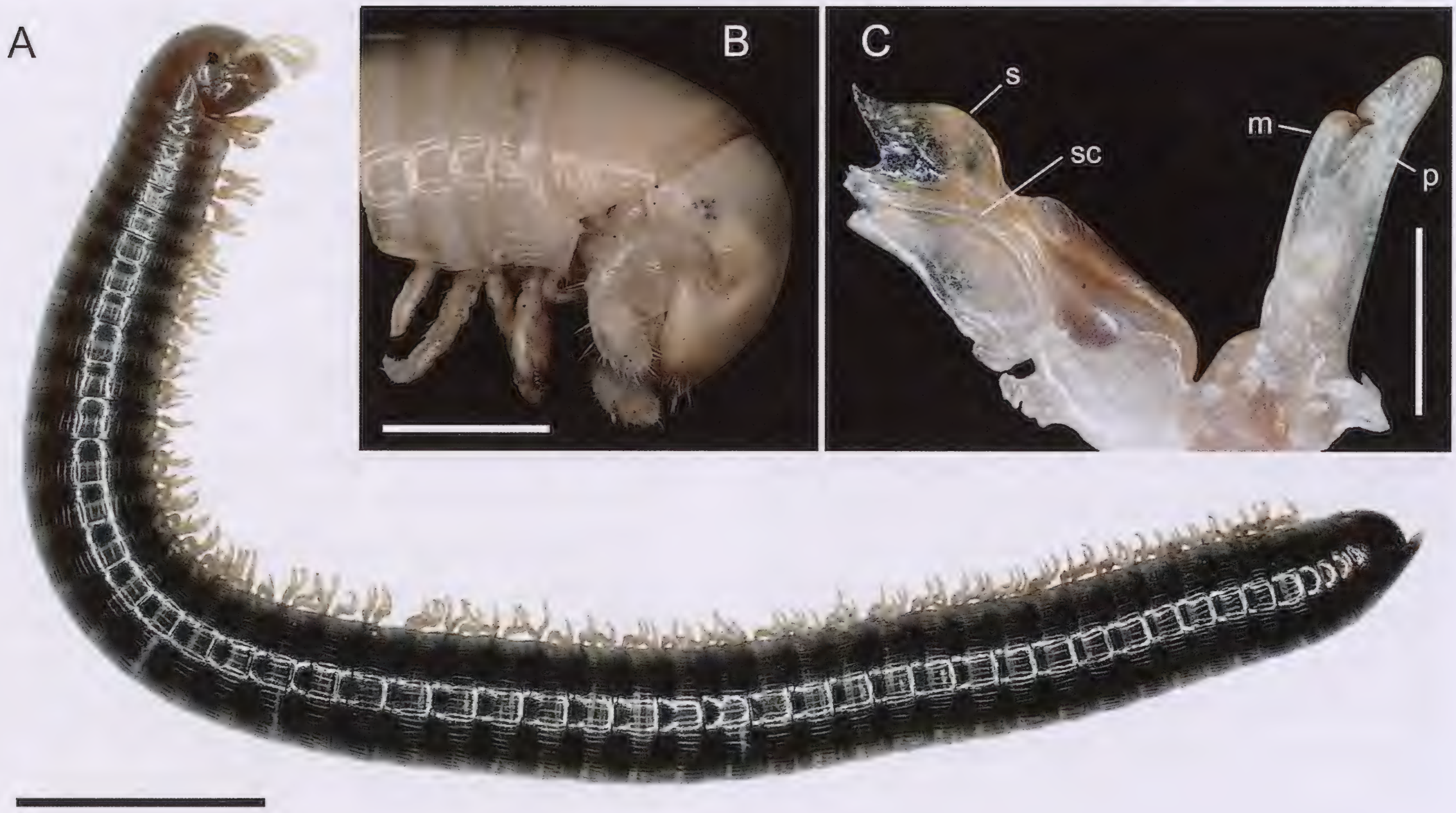


Fig. 2. *Cylindroiulus salicivorus* Verhoeff, 1908. (A) Adult female from Binningen (NMB-700b). Colour darkened due to preservation. Scale bar 2 mm. (B) Detail of head and anterior part of trunk of dissected male from Basel-Stadt (NMB-700a). Scale bar 0.5 mm. (C) Gonopod of same male specimen in lateral view. Scale bar 0.2 mm. Abbreviations: m, mesomerite; p, promerite; s, solenomerite; sc, sperm channel.

Distribution: Germany, Great Britain, Italy (Kime & Enghoff, 2017).

Remarks: *Cylindroiulus salicivorus* seems to naturally occur south of the Alps, were it has been recorded from wet grasslands with *Salix* trees and from humus beneath *Castanea* trees. The records from Scotland are from botanical gardens (Lee, 2006), and the record from Germany is from Karlsruhe Palace (Spelda, 2005), suggesting that it was introduced to these two locations (Kime & Enghoff, 2017).

Cylindroiulus vulnerarius (Berlese, 1888)

Fig. 3

Mesoiulus vulnerarius Berlese, 1888.
Typhloiulus vulnerarius (Berlese, 1888): auct.
Cylindroiulus ellingseni Verhoeff, 1912.

Material examined: NMB-701a; 1 male; Switzerland, Basel-Landschaft, Binningen, private garden, 47°32′09.67″N, 7°34′38.27″E, 300 m; 01.06.2018; J. D. Gilgado *et al.* leg.; active capture. – NMB-701b; 3 females; Switzerland, Basel-Landschaft, Binningen, private garden, 47°32′01.31″N, 7°34′52.79″E, 345 m; 10.08.2018; J. D. Gilgado *et al.* leg.; active capture. – NMB-701c; 1 juvenile; same data but 28.09.2018.

Distribution: Belgium, British Isles, Czech Republic, France, Germany, Italy, the Netherlands, Sweden. Also introduced into North America (Kime & Enghoff, 2017).

Remarks: This species is usually found in decaying wood and organic matter (such as compost or debris) in contact with the soil. *Cylindroiulus vulnerarius* has probably an Italian origin, since most records outside this country are in urban or suburban environments (Kime & Enghoff, 2017). However, as inferred from its presence in caves in Belgium and its abundance in the Netherlands and the British Isles, it is possible that in these areas this species had survived recent glaciations in microrefugia (Kime, 2004; Kime & Dethier, 2010; Kime & Enghoff, 2017).

Genus *Heteroiulus* Verhoeff, 1897

Heteroiulus intermedius (Brölemannn, 1892)

Fig. 4

Julus intermedius Brölemann, 1892.
Allajulus salvadorii Silvestri, 1896.

Material examined: NMB-272b; 1 male; Switzerland, Ticino, Bellinzona, forest close to settlements, 46°12′06.61″N, 9°02′17.88″E, 265 m; 01.04.2018; J.

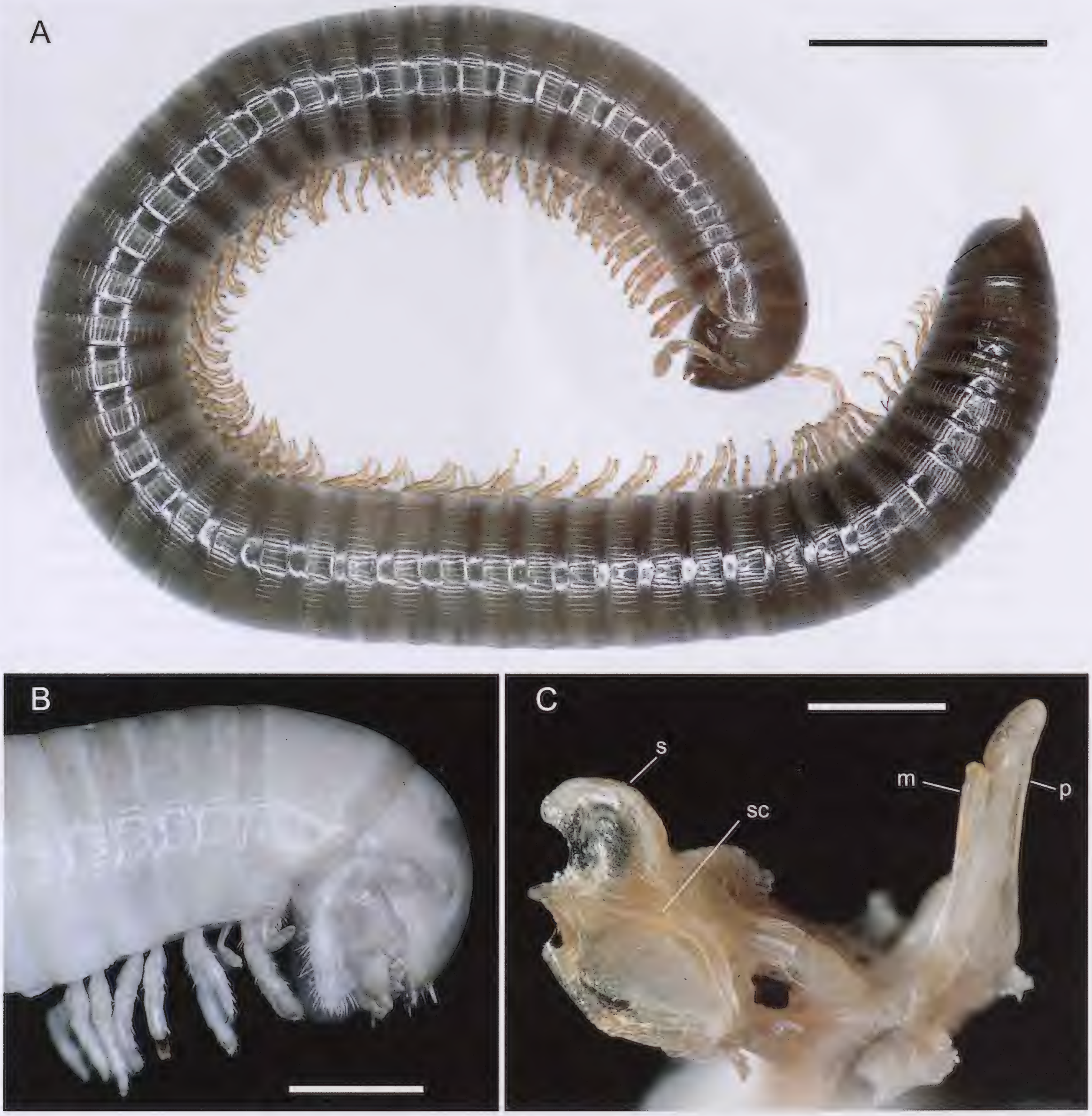


Fig. 3. *Cylindroiulus vulnerarius* (Berlese, 1888). (A) Adult female from Binningen (NMB-701b). Scale bar 2 mm. (B) Detail of head and anterior part of trunk of male (NMB-701a). Scale bar 0.5 mm. (C) Gonopod of same specimen in lateral view. Scale bar 0.2 mm. Abbreviations: m, mesomerite; p, promerite; s, solenomerite; sc, sperm channel.

D. Gilgado & V. Martínez-Pillado leg.; active capture under a stone.

Distribution: Northern Italy (Kime & Enghoff, 2017).

Remarks: This species is known to inhabit the deep and decomposed litter layer in *Castanea*, *Carpinus* and *Quercus* forests (Kime & Enghoff, 2017).

Order Chordeumatida Pocock, 1894
Family Anthroleucosomatidae Verhoeff, 1899
***Anamastigona pulchella* (Silvestri, 1894)**
Fig. 5

Craspedosoma pulchellum Silvestri, 1894.
Anamastigona attemsi Verhoeff, 1900.

Material examined: NMB-702a; 4 juveniles; Switzerland, Basel-Stadt, meadow beside forest

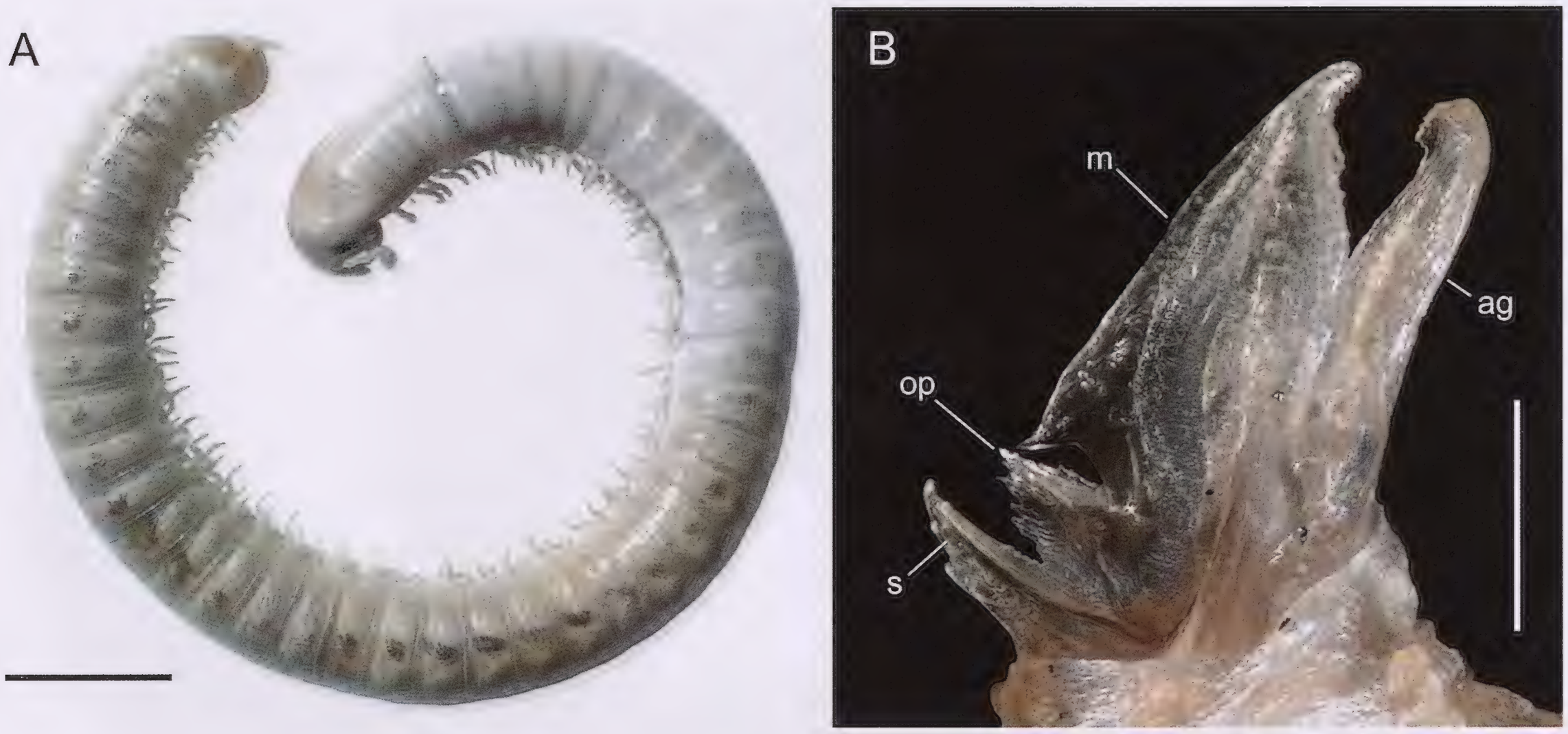


Fig. 4. *Heteroiulus intermedius* (Brölemannn, 1892). (A) Dissected adult male from Bellinzona (NMB-272b). Scale bar 1 mm. (B) Gonopod of same male specimen in lateral view. Abbreviations modified after Enghoff *et al*. (2013): ag, anterior gonopod; m, mesomerite; op, "opuntia-like" appendage; s, solenomerite. Scale bar 0.1 mm.

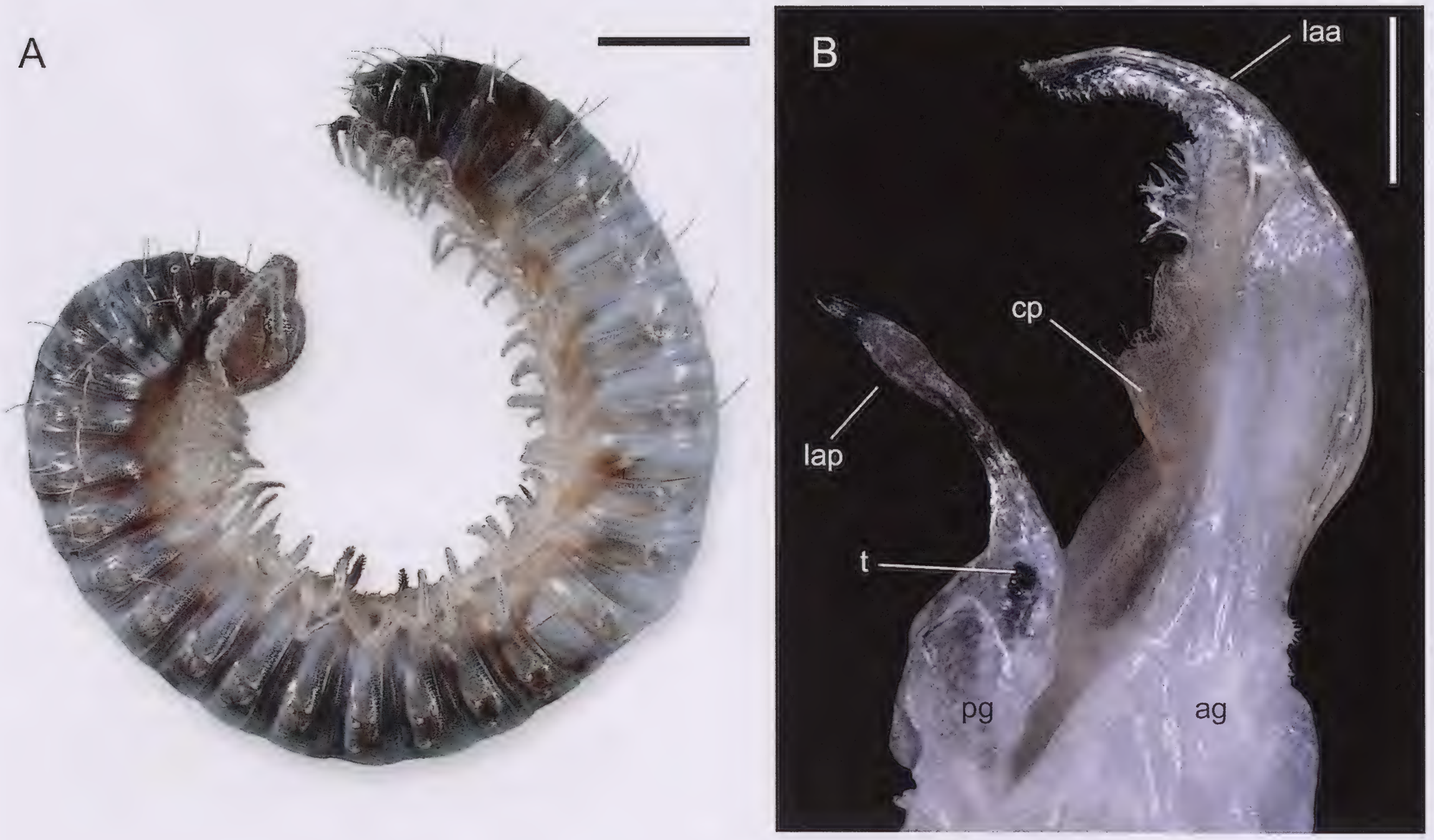


Fig. 5. *Anamastigona pulchella* (Silvestri, 1894). (A) Adult female from Basel-Stadt (NMB-702e). Several setae are missing, and the colour is faded because of handling and preservation, respectively. Scale bar 1 mm. (B) Gonopod of male (NMB-702g) in lateral view. Scale bar 0.1 mm. Abbreviations: ag, anterior gonopod; cp, colpocoxite; laa, lateral arm of anterior gonopod; lap, lateral arm of posterior gonopod; t, telopodite; pg, posterior gonopod.

fragment, 47°34′21.20″N, 7°36′52.43″E, 255 m; 26.06.2014; B. Braschler & R. Melliger leg.; pitfall trap. – NMB-702b; 4 juveniles; Switzerland, Basel-Stadt, forest fragment, 47°34′20.57″N, 7°36′52.45″E, 255 m; 03.07.2014; B. Braschler & R. Melliger leg.; pitfall trap. – NMB-702c; 1 male; same data but 21.10.2017; J. D. Gilgado leg.; active capture, gonopods on microscope slide mount. – NMB-702d; 1 male; same data but 21.10.2017; J. D. Gilgado leg.; active capture, gonopods on microscope slide mount. – NMB-702e; 4 females, 38 juveniles; same data but 17.01.2018; J. D. Gilgado leg.; hay bait. – NMB-702f; 1 subadult male, 8 juveniles; same data but 14.05.2018; J. D. Gilgado leg.; active capture. – NMB-702g; 3 males; same data but 30.10.2018; J. D. Gilgado leg.; active capture. – NMB-702h; 2 juveniles; Switzerland, Basel-Stadt, grassland in park, 47°33′52.08″N, 7°37′59.08″E, 265 m; 02.07.2014; B. Braschler & R. Melliger leg.; pitfall trap. – NMB-702i; 1 female; same data but 01.10.2014. – NMB-702j; 1 juvenile; Switzerland, Basel-Stadt, forest fragment, 47°31′44.71″N, 7°36′09.39″E, 310 m; 14.07.2014; B. Braschler & R. Melliger leg.; pitfall trap. – NMB-702k; 2 females; same data but 29.09.2014. – NMB-702l; 1 subadult male, 3 females; Switzerland, Basel-Landschaft, Binningen, private garden, 47°32′07.63″N, 7°33′40.24″E, 345 m; 04.10.2018; J. D. Gilgado *et al.* leg.; active capture. – NMB-702m; 3 females; same data but 27.09.2018.

Distribution: British Isles, France, Germany, Italy and Portugal (including Madeira) (Gregory *et al.,* 2015).

Remarks: This species seems to be native to central and southern Italy, and it has spread due to human activity (Lindner *et al.,* 2010). In the British Isles it can be found in cultivated or anthropized woodlands, gardens and parks, in deadwood and leaf litter, under moss, or in soil interstices, showing a preference for damp localities (Gregory *et al.,* 2015). In Germany it was found under deadwood in a resting area of a highway, close to ornamental flower beds (Lindner *et al.,* 2010).

Order Polydesmida Leach, 1815
Family Macrosternodesmidae Brölemann, 1916
Genus *Macrosternodesmus* Brölemann, 1908
Macrosternodesmus palicola Brölemann, 1908

Fig. 6

Macrosternodesmus palicola Brölemann, 1908.
Titanosoma jurassicum Verhoeff, 1910.

Material examined: NMB-703a; 1 male; Switzerland, Basel-Stadt, private garden, 47°33′40.182″N, 7°34′42.937″E, 270 m; 31.05.2018; J. D. Gilgado *et al.* leg.; active capture. – NMB-703b; 1 female; same data but 07.06.2018. – NMB-703c; 1 female; Switzerland, Basel-Landschaft, Binningen, private garden, 47°32′01.31″N, 7°34′52.79″E, 345 m; 01.06.2018; J. D. Gilgado *et al.* leg.; active capture.

Distribution: France, Belgium, British Isles, Czech Republic, Denmark, Germany, Luxembourg, the Netherlands, Norway and Sweden (Kime & Enghoff, 2011; Tajovský & Tuf, 2016).

Remarks: This is a very small millipedes species, only up to 4 mm long (Blower, 1985). According to Kime & Enghoff (2011) this species has an Atlantic distribution and may be originally native to deciduous woodlands (mostly *Fagus* forests) on calcareous soils. However, nowadays most records of this species are from human-made biotopes.

Fig. 6. *Macrosternodesmus palicola* Brölemann, 1908. (A) Adult female from Binningen (NMB-703c). Scale bar 1 mm. (B) Gonopods of male (NMB-703a) from Basel in ventral view. Scale bar 0.1 mm. Abbreviations: pf, prefemoral part of telopodite; t, telopodite; tt, tip of telopodite; s, solenomerite; sl, subrectangular lamella.

DISCUSSION

Sampling efficiency

Despite using several methods for millipede sampling in the gardens in 2018, all specimens of five newly recorded species (*C. britannicus*, *C. salicivorus*, *C. vulnerarius*, *A. pulchella* and *M. palicola*) were exclusively collected by active search. The fact that hay baits did not capture specimens of these species in gardens could be explained by their short exposure period (1 week). Tuf *et al.* (2015) showed a peak in the millipede richness attracted by hay baits after an exposure of eight weeks. Furthermore, the weather conditions during summer led to some hay baits going dry soon and thus probably becoming ineffective. Therefore including hand collecting seems to be the best way not to miss the less abundant species, at least with trap exposure times of only a week. This is probably why the study by Vilisics *et al.* (2012) carried out with pitfall traps in gardens of Zurich, Lugano and Luzern found only 10 common millipede species.

Species origin and distribution

All six newly recorded species have a European origin. All except *H. intermedius* are synanthropic in at least a part of their distribution range. This characteristic, together with their absence in the checklist of Pedroli-Christen (1993), suggests a recent introduction into Switzerland by humans. The most probable way of introduction is the trade of cultivated plants and soil material in greenhouses for gardening. This is likely the most common way of introduction for millipedes in general, including those from tropical areas (Stoev *et al.,* 2010). More detailed information on each species is given below.

Cylindroiulus britannicus seems to have a Lusitanian or Atlantic origin and it is expanding its geographical range across the world (Kime & Enghoff, 2017). Its presence in gardens in Basel suggests human introduction and most likely it arrived quite recently. The presence of this species in agricultural land in Liestal suggests that the species may also be able to colonise semi-natural areas.

Cylindroiulus salicivorus is native to northern Italy, and its previously recorded localities north of the Alps [two in Scotland (Lee, 2006), one in Germany (Spelda, 2005)], like the location in Basel, are all in human-made environments. This is thus very likely a species introduced to Switzerland. Records of *C. salicivorus* outside its native range are scarce, so to date its potential to colonise new areas seems to be low.

Cylindroiulus vulnerarius has probably also an Italian origin, and outside this range the species is mostly synanthropic (Kime & Enghoff, 2017). Even, as it has been hypothesized, if this species has survived the glaciations in microrefugia in some parts of Europe (Kime, 2004; Kime & Dethier, 2010; Kime & Enghoff, 2017), it has a high "dispersal ability" and is very likely a newcomer to Switzerland.

Heteroiulus intermedius was found in southern Switzerland, and its known distribution range in northern Italy is approximately at the same latitude (or at most 30 km more southern) as the Swiss locality (Kime & Enghoff, 2017). It was found close to settlements and close to the railway station in the town of Bellinzona. The latter find is in a forested area in the lower part of a mountain slope. While it could be an introduced species, its distribution range suggests that it is likely a native species in Switzerland.

Anamastigona pulchella also has an Italian origin, and it seems to be expanding its geographical range due to human activity (Lindner *et al.,* 2010). It was found synanthropic at four localities in Basel, in one garden, in urban forests and urban grasslands. This suggests a human introduction in Switzerland. *Anamastigona pulchella* does not seem to be a rare species in Basel and may be found in more localities in the country. Although Lindner *et al.* (2010) claim that the species is probably not invasive despite its plasticity, attention should be paid to its range expansion.

Macrosternodesmus palicola is a species of very small millipedes and thus easily overlooked. At natural sites, mostly in the southern and western part of its distribution range, it has been found in *Fagus* forests on calcareous soils (Kime & Enghoff, 2011), a type of habitat also present in the region of Basel. However, the species was found only in gardens in Basel and most of its records elsewhere are from human-made habitats (Kime & Enghoff, 2011). Therefore it is possible that this species occurs naturally in Switzerland, but more likely it arrived recently.

Ecological implications

These six newly recorded species represent an increase of 4.8% in the previously known number of Swiss millipede species (125 species, excluding greenhouse species; Pedroli-Christen, 1993; Bogyó *et al*., 2013). In general, introduced millipedes in Europe pose a minor threat to biodiversity and to human economic activities (Stoev *et al.,* 2010). However, ongoing climate change is strongly affecting central Europe (Beniston *et al.,* 1994; Scherrer *et al.,* 2006; Rebetez & Reinhard, 2008) and this may promote invasions by millipedes from warmer regions in the future. There is at least one example of an invasive millipede species that was once restricted to greenhouses and is nowadays able to colonise outdoor locations in Europe: the introduced Asian species *Oxidus gracilis*. This species is considered as a pest in several countries of Europe because of the damage it causes to several cultivated plants (Stoev *et al.,* 2010). *Oxidus gracilis* was found in Europe at the end of the 19th century and the beginning of the 20th century (Tömösváry, 1879; Latzel, 1884; Evans, 1900; Pocock, 1902), and it was reported for the first time in Basel by Bigler (1913). At

that time it only occurred in greenhouses. Less than 30 years ago, *O. gracilis* was known from three localities in Switzerland (Basel, Bern and the island of Brissago in the canton of Ticino), mostly from greenhouses or botanical gardens, and rarely from gardens and compost heaps (Pedroli-Christen, 1993). However, nowadays it widely occurs outdoors in Switzerland. It is known to infest gardens in rural areas (Macbeth, 2018), and today it is one of the most frequent and abundant species in gardens in Basel (*in preparation*). *Oxidus gracilis* seems to be sensitive to long exposures to temperatures below 0 °C (Causey, 1943; Palmén, 1949), therefore the reason behind the increase of its frequency and abundance in Switzerland is likely related to more favourable climatic conditions during winter (Beniston *et al.,* 1994; Scherrer *et al.,* 2006; Rebetez & Reinhard, 2008). What happened with *O. gracilis* (arrival in greenhouses, establishment outdoors in urban areas and becoming a pest) could be repeated in the future with other species of introduced millipedes in Switzerland. The lack of Swiss millipede specialists may be hindering our follow up on the actual abundance and distribution of native and alien millipede species in the country, and little is known on how climate change may be affecting them and their distribution ranges in Switzerland.

ACKNOWLEDGEMENTS

Special thanks are due to all the garden owners that kindly allowed us to survey invertebrate diversity on their properties. Thanks also go to the people who participated in the design and implementation of the surveys in the garden project (Bruno Baur, Brigitte Braschler, Hans-Peter Rusterholz and Valerie Zwahlen) and in the fieldwork and processing of the samples (Martin Baur, Min Jenny Chai, Josephine Edwards, Vanessa Ingold, Virginia Martínez-Pillado, Vivian Nedweg, Evelin Pandiamakkal, Calum Ramage, Dimitri Schärer, Luca Yapura, Irmgard Zwahlen and Valerie Zwahlen). I am also grateful to Brigitte Braschler and Ramona Melliger for providing the samples of the forest and grassland pitfall trap surveys made in 2014. Many thanks to Virginia Martínez-Pillado for help in collecting *H. intermedius*. I am especially thankful to Henrik Enghoff for identifying the first specimen of *C. salicivorus* available to me, and to Hans Reip for identifying the first specimen of *A. pulchella.* This work has been funded by the Department of Environmental Sciences of the University of Basel and the Basler Stiftung für Experimentelle Zoologie. Also many thanks to Brigitte Braschler and Bruno Baur for their comments on an earlier draft of the manuscript, and to Edi Stöckli for providing reference numbers for the repository of the examined specimens in the Naturhistorisches Museum Basel. I am also grateful to the subject editor, Peter Schwendinger, and an anonymous referee for their comments on and corrections to the manuscript.

REFERENCES

Attems C. 1904. Neue palaearktische Myriopoden nebsts Beiträgen zur Kenntnis einiger alten Arten. *Archiv für Naturgeschichte* 70(1): 179-196.

Attems C. 1933. VII. Myriapodes. *In*: Voyage de MM. L. Chopard et A. Méquignon aux Açores. *Annales de la Société entomologique de France* 102: 23-24.

Beniston M., Rebetez M., Giorgi F., Marinucci M.R. 1994. An analysis of regional climate change in Switzerland. *Theoretical and Applied Climatology* 49(3): 135-159.

Berlese A. 1888. Acari, Myriopoda et Scorpiones hucusque in Italia reperta. Volumen VI. Fasc. LI-LX. *Sumptibus Auctoris, Padova*, 10 pp.

Bigler W. 1913. Die Diplopoden von Basel und Umgebung. *Revue suisse de Zoologie* 21: 675-793.

Blower J.G. 1985. Millipedes: keys and notes for the identification of the species. Vol. 35. *In*: Kermack D.M., Barnes R.S.K. (eds), Synopses of the British Fauna, new series. *Linnean Society, London,* 242 pp.

Bogyó D., Vilisics F., Moretti M., Trivellone V. 2013. Isopoda and Diplopoda fauna of vineyards in Southeast-Switzerland (p. 14). *In*: Abstract book of the 12th Central European Workshop on soil zoology in České Budějovice, Czech Republic.

Brandt J.F. 1833. Tentaminum quorundam monographicorum Insecta Myriapoda Chilognathi Latreillii spectantium prodromus. *Bulletin de la Société Impériale des Naturalistes de Moscou* 6: 194-209.

Brewer M.S., Sierwald P., Bond J.E. 2012. Millipede taxonomy after 250 years: classification and taxonomic practices in a mega-diverse yet understudied arthropod group. *PLoS One* 7(5): e37240.

Brölemann H.W. 1892. Contributions à la faune myriapodologique méditerranéenne. Dix espèces nouvelles. *Annales de la Société Linnéenne de Lyon* 29: 91-126.

Brölemann H.W. 1908. Description d'un genre nouveau et d'une espèce nouvelle de Myriapodes de France. *Bulletin de la Société entomologique de France* 1908(7): 94-96.

Brölemann H.W. 1916. Essai de classification des Polydesmiens. *Annales de la Société entomologique de France* 84: 523-608.

Cárcamo H.A., Abe T.A., Prescott C.E., Holl F.B., Chanway C.P. 2000. Influence of millipedes on litter decomposition, N mineralization, and microbial communities in a coastal forest in British Columbia, Canada. *Canadian Journal of Forest Research* 30(5): 817-826.

Causey N.B. 1943. Studies on the life history and the ecology of the hothouse millipede, *Orthomorpha gracilis* (CL Koch 1847). *American Midland Naturalist* 29(3): 670-682.

David J.F. 2015. Diplopoda - Ecology [pp. 303-327]. *In*: Minelli A. (ed.). Treatise on Zoology-Anatomy, Taxonomy, Biology. The Myriapoda, volume 2. *Brill, Leiden-Boston*, X+482 pp.

Enghoff H. 2015. Diplopoda - geographical distribution [pp. 329-336]. *In*: Minelli A. (ed.). Treatise on Zoology-Anatomy, Taxonomy, Biology. The Myriapoda, volume 2. *Brill, Leiden-Boston*, X+482 pp.

Enghoff H., Petersen G., Seberg O. 2013. The aberrant millipede genus *Pteridoiulus* and its position in a revised molecular phylogeny of the family Julidae (Diplopoda: Julida). *Invertebrate Systematics* 27(5): 515-529.

Enghoff H., Golovatch S., Short M., Stoev P., Wesener T. 2015.

Diplopoda - taxonomic overview [pp. 363-453]. *In*: Minelli A. (ed.). Treatise on Zoology-Anatomy, Taxonomy, Biology. The Myriapoda, volume 2. *Brill, Leiden-Boston*, X+482 pp.

Evans W. 1900. Scottish Myriapoda. *The Annals of Scottish Natural History* 1900: 127.

Golovatch S.I., Kime R.D. 2009. Millipede (Diplopoda) distributions: A review. *Soil Organisms* 81(3): 565-597.

Gregory S.J., Davidson M.B., Owen C., Anderson R. 2015. *Anamastigona pulchella* (Silvestri, 1894) – first British records for England, Scotland and Wales (Chordeumatida: Anthroleucosomatidae). *Bulletin of the British Myriapod & Isopod Group* 28: 31-37.

Hoess R. 2000. Bestimmungsschlüssel für die *Glomeris*-Arten Mitteleuropas und angrenzender Gebiete (Diplopoda: Glomeridae). *Jahrbuch des Naturhistorischen Museums Bern* 13: 3-20.

Hoess R., Scholl A. 1999. *Glomeris undulata* Koch and *Glomeris conspersa* Koch are conspecific. - Enzyme electrophoretic evidence and taxonomical consequences (Diplopoda: Glomeridae). *Revue suisse de Zoologie* 106(3): 643-661.

Hoess R., Scholl A. 2001. Allozyme and literature study of *Glomeris guttata* Risso, 1826, and *G. connexa* Koch, 1847, a case of taxonomic confusion (Diplopoda: Glomeridae). *Zoologischer Anzeiger* 240(1): 15-33.

Hoffman R. 1980. Classification of the Diplopoda. *Muséum d'histoire naturelle, Genève*, 237 pp.

Kime R.D. 2004. The Belgian millipede fauna. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Entomologie* 74: 35-68.

Kime R.D., Dethier M. 2010. Les Myriapodes des milieux souterrains de Belgique. *Bulletin des Chercheurs de la Wallonie* hors-série 3: 67-78.

Kime R.D., Enghoff H. 2011. Atlas of European millipedes (Class Diplopoda), vol. 1: orders Polyxenida, Glomerida, Platydesmida, Siphonocryptidae, Polyzoniida, Callipodida, Polydesmida. *Pensoft Publishers, Sofia*, 282 pp.

Kime R.D., Enghoff H. 2017. Atlas of European millipedes, vol. 2: order Julida (class Diplopoda). *European Journal of Taxonomy* 346: 1-299.

Koch C.L. 1847. System der Myriapoden mit den Verzeichnissen und Berichtigungen zu Deutschlands Crustaceen, Myriapoden und Arachniden [pp. 1-196]. *In*: Panzer K., Herrich-Schäffer A. (eds). Kritische Revision der Insectenfauna Deutschlands, III. Bändchen. *Pustet, Regensburg*, 270 pp.

Latzel R. 1884. Die Myriapoden der Österreichisch-Ungarischen Monarchie. 2. Bd.: Die Symphylen, Pauropoden und Diplopoden. *Alfred Hölder, Wien,* 414 pp.

Leach W.E. 1814. Crustaceology. *In*: Brewster D. (ed.). *The Edinburgh Encyclopaedia* 7: 383-437.

Leach W.E. 1815. A tabular view of the external characters of four classes of animals, which Linn. arranged under Insecta; with the distribution of the genera composing three of these classes into orders, &c. and descriptions of several new genera and species. *Transactions of the Linnean Society of London* 11: 306-400.

Lee P. 2006. Atlas of the Millipedes (Diplopoda) of Britain and Ireland. *Pensoft, Sofia*, 216 pp.

Lindner E.N., Reip H.S. Spelda J. 2010. *Anamastigona pulchella* (Silvestri, 1898) (Diplopoda: Chordeumatida: Anthroleucosomatidae) - ein für Deutschland neuer Tausendfüßer. *Schubartiana* 4: 1-8.

Macbeth A. 2018. Plague of secreting millipedes of Asian origin tormenting Swiss village. Available at https://www.thelocal.ch/20180726/plague-of-secreting-millipedes-of-asian-origin-tormenting-swiss-village (accessed on 15 December 2019).

Melliger R.L., Braschler B., Rusterholz H.-P., Baur B. 2018. Diverse effects of degree of urbanisation and forest size on species richness and functional diversity of plants, and ground surface-active ants and spiders. *PloS One* 13(6): e0199245.

Palmén E. 1949. The Diplopoda of Eastern Fennoscandia. *Annales zoologici Societatis zoologicobotanicae fennicae Vanamo* 13(6): 1-53.

Pedroli-Christen A. 1993. Faunistique des mille-pattes de Suisse (Diplopoda). *Documenta Faunistica Helvetiae* 14: 1-167.

Pedroli-Christen A., Scholl A. 1996. *Rhymogona* (Diplopoda: Craspedosomatidae) un genre monospécifique. Deuxième partie: Révision basée sur les résultats morphologiques, génétiques et faunistiques [pp. 53-60]. *In*: Geoffroy J.-J., Mauriès J.-P., Nguyen Duy-Jacquemin M. (eds). Acta Myriapodologica. *Mémoires du Muséum National d'Histoire Naturelle* N. S. 169: 1-682.

Pocock R.I. 1894. Chilopoda, Symphyla and Diplopoda from the Malay Archipelago [pp. 307-404]. *In*: Weber M. (ed.). Zoologische Ergebnisse einer Reise in Niederländisch Ost-Indien, Band 3. *Brill, Leiden,* 476 pp.

Pocock R.I. 1902. Myriapoda. *The Victoria History of the County of Surrey* 1: 176-178.

Rebetez M., Reinhard M. 2008. Monthly air temperature trends in Switzerland 1901-2000 and 1975-2004. *Theoretical and Applied Climatology* 91(1-4): 27-34.

Scherrer S.C., Appenzeller C., Liniger M.A. 2006. Temperature trends in Switzerland and Europe: Implications for climate normals. *International Journal of Climatology* 26(5): 565-580.

Silvestri F. 1894. Contribuzione alla conoscenza dei Chilopodi, Symphili, Pauropodi e Diplopodi dell'Umbria e del Lazio. *Bollettino della Società Romana per gli Studi Zoologici* 3(5-6): 191-201.

Silvestri F. 1896. Nuovo Diplopodi e Chilopodi dell'Italia settentrionale. *Bollettino del musei di zoologia e di anatomia comparata della Reale Università di Torino* 11(233): 1-5.

Spelda J. 2005. Improvements in the knowledge of the myriapod fauna of southern Germany between 1988 and 2005 (Myriapoda: Chilopoda, Diplopoda, Pauropoda, Symphyla). *Peckiana* 4: 101-129.

Stoev P., Zapparoli M., Golovatch S., Enghoff H., Akkari N., Barber A. 2010. Myriapods (Myriapoda). Chapter 7.2. *BioRisk* 4(1): 97-130.

Stojalowska W., Pedroli-Christen A. 1996. The taxa of *Rhymogona* (Diplopoda: Craspedosomatidae): a ring species. Part one: Genetic analysis of population structure [pp. 45-51]. *In*: Geoffroy J.-J., Mauriès J.-P., Nguyen Duy-Jacquemin M. (eds). Acta Myriapodologica. *Mémoires du Muséum National d'Histoire Naturelle* N.S. 169: 1-682.

Tajovský K., Tuf I.H. 2016. An annotated checklist of the millipedes (Diplopoda) recorded in the Czech Republic. *Acta Societatis Zoologicae Bohemicae* 80(1): 33-37.

Tömösváry Ö. 1879. Néhány hazánkban előforduló Myriopodáról. *Orvos-Természettudományi Értesitő, Kolozsvár* 3: 22-25.

Tuf I.H., Chmelík V., Dobroruka I., Hábová L., Hudcová P., Šipoš J., Stašiov S. 2015. Hay-bait traps are a useful tool for

sampling of soil dwelling millipedes and centipedes. *ZooKeys* 510: 197-207.

Verhoeff K.W. 1891. Ein Beitrag zur mitteleuropäischen Diplopodenfauna. *Berliner entomologische Zeitschrift* 36(1): 115-166.

Verhoeff K.W. 1894. Beiträge zur Diplopoden-Fauna Tirols. *Verhandlungen der Zoologisch-botanischen Gesellschaft in Wien* 44: 9-34.

Verhoeff K.W. 1897 (for 1896). Beiträge zur Kenntnis paläarktischer Myriopoden. IV. Aufsatz: Ueber Diplopoden Tirols, der Ostalpen und anderer Gegenden Europas, nebst vergleichend-morphologischen und biologischen Beobachtungen. *Archiv für Naturgeschichte* 62(3): 187-242.

Verhoeff K.W. 1899. Beiträge zur Kenntniss paläarktischer Myriopoden. VIII. Aufsatz: Zur vergleichenden Morphologie, Phylogenie, Gruppen- und Art-Systematik der Chordeumiden. *Archiv für Naturgeschichte* 65(1): 138-219.

Verhoeff K.W. 1900. Beiträge zur Kenntnis paläarktischer Myriopoden. XIII. Aufsatz: Zur vergleichenden Morphologie, Phylogenie, Gruppen- und Art-Systematik der Ascospermophora. *Archiv für Naturgeschichte* 66(1): 347-402.

Verhoeff K.W. 1907. Über Diplopoden. 7. (27.) Aufsatz: Europäische Polydesmiden. *Zoologischer Anzeiger* 32(12-13): 337-354.

Verhoeff K.W. 1908. Über Diplopoden. 10. (30.) Aufsatz: Zur Kenntnis der Juliden und über einige Polydesmiden. *Archiv für Naturgeschichte* 73(1): 423-474.

Verhoeff K.W. 1910. Über Diplopoden. 42. Aufsatz: Neue Polydesmiden aus Mitteleuropa und ihre Verwandten. *Zoologischer Anzeiger* 36(6-7): 132-145.

Verhoeff K.W. 1912. Zwei neue mitteleuropäische *Cylindroiulus*-Arten. (Über Diplopoden, 55. Aufsatz.). *Zoologischer Anzeiger* 40(8-9): 220-227.

Verhoeff K.W. 1930. Über Diplopoden aus Italien, namentlich Piemont. 114. Diplopoden-Aufsatz. *Zoologische Jahrbücher, Abteilung für Systematik, Ökologie und Geographie der Tiere* 59: 387-446.

Vilisics F., Bogyó D., Sattler T., Moretti M. 2012. Occurrence and assemblage composition of millipedes (Myriapoda, Diplopoda) and terrestrial isopods (Crustacea, Isopoda, Oniscidea) in urban areas of Switzerland. *ZooKeys* 176: 199-214.

Wittenberg R. (ed.). 2005. An inventory of alien species and their threat to biodiversity and economy in Switzerland. CABI Bioscience Switzerland Centre report to the Swiss Agency for Environment, Forests and Landscape. The environment in practice no. 0629. *Federal Office for the Environment, Bern*, 417 pp.

Revue suisse de Zoologie (September 2020) 127(2): 261-274 ISSN 0035-418

Helminth communities from amphibians inhabiting agroecosystems in the Pampean Region (Argentina)

Regina Draghi[1,3,*], Fabiana B. Drago[1,4], Pablo E. Saibene[5] & M. Gabriela Agostini[2,3]

[1] *División Zoología de Invertebrados, Museo de La Plata, UNLP, Paseo del Bosque s/no -B1900FWA La Plata, Argentina. ORCID iD: https://orcid.org/0000-0002-3119-3904*
[2] *Universidad de Buenos Aires-CONICET. Instituto de Ecología, Genética y Evolución de Buenos Aires. GEBA. Ciudad Universitaria. Pabellón II. Güiraldes 2160, C1428EGA. CABA, Argentina.*
[3] *Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)*
[4] *Comisión de Investigaciones Científicas de la provincia de Buenos Aires (CIC)*
[5] *Conservación de Anfibios en Agroecosistemas (COANA)*
* *Corresponding autor: rdraghi@fcnym.unlp.edu.ar*

Abstract

The objectives of this study were to describe the composition and infection patterns of the helminth communities associated with four amphibians (*P. minuta*, *B. pulchella*, *L. latrans* and *R. fernandezae*) with different life-habits, and additionally to compare the helmith fauna associated with these amphibians in agroecosystems with different land use (crops and livestock). A total of 300 anuran individuals and twelve helminth taxa were collected in sites located northeast of the Province of Buenos Aires, Argentina. Helminth communities differed between amphibian species according to their habitat preference, digeneans were predominant in aquatic and arboreal amphibians (Hylidae) and nematodes with direct life cycle were found parasitizing semi-aquatic and terrestrial amphibians (Leptodactylidae and Bufonidae). In three of the frog species (*B. pulchella*, *L. latrans* and *R. fernandezae*), parasite prevalence did not vary significantly according to land use. The values of abundance and infracommunity species richness, meanwhile, varied according to land use, with the highest abundance values in crop sites and higher richness in livestock sites. Regardless of the use of land, *L. latrans* presented the highest values of prevalence, abundance, and richness of helminth species. This is the first study assessing the ecological aspects of parasite taxa in populations of *P. minuta*, *B. pulchella* and *L. latrans* that inhabit agroecosystems in Argentina.

Keywords

Helminth communities, amphibians, Pampean Region, Argentina.

INTRODUCTION

As established by Aho (1990), because amphibians have invaded a great variety of habitats and exhibit numerous patterns of life histories, reproductive modes, body size, and trophic relationships, they are excellent systems for exploring patterns and processes that influence the organization of helminth communities. By acting as generalist predators and as preys, amphibians play a role as intermediate and definitive hosts of a great variety of parasites in the aquatic and terrestrial food chains (Koprivnikar *et al*., 2012).

Among the biological characteristics of the hosts, sex has been listed influencing the number and abundance of parasitic species in vertebrates (Poulin, 1996). Differences in size, reproductive behaviour, microhabitat preference and hormonal levels related to sex, can affect the exposure of amphibians to the infective stages of parasites. This could be due to a larger colonization area (more space and resources for larger amphibians) or for a longer exposure time, for example, when males vocalize from water during the reproductive periods (Aho, 1990; McAlpine, 1997; Hamann *et al*., 2006a, b, 2012, 2013, 2014b).

For just over a decade, and with the establishment of the environmental parasitology as a discipline, emphasis has been placed on the role of parasites as indicators of environmental changes, demonstrating significant effects

Manuscript accepted 15.06.2020
DOI: 10.35929/RSZ.0020

and interactions between different parasite indices and the presence and concentration of pollutants and/or environmental stressors (Poulin, 1992; Marcogliese & Cone, 1997; Marcogliese, 2005). Several authors suggest that changes in macroparasitic infections have potential as a tool in conservation research of amphibians (Sures, 2004; McKenzie, 2007; Marcogliese & Pietrock, 2011; Koprivnikar *et al*., 2012).

The Pampean Region, one of the richest agricultural areas of the world, has undergone a drastic anthropogenic intervention during the nineties, with the intensification of land use, the replacement of lands used for livestock by soybean crops, and the concomitant increased in the use of pesticides (insecticides, herbicides) (Agostini & Burrowes, 2015). In addition, during the past two decades the peri-urban intensive production of vegetables has increased around big cities and, in search of greater productivity, it generates a greater use of chemical fertilizers to sustain these productive levels (Defensor del pueblo de la Provincia de Buenos Aires, 2015). These changes have increased the pesticide pollution of wetlands and aquifers, the risk of release to the environment of fertilizers residues and habitat loss, with a negative impact on habitat and wildlife (Herrera *et al*., 2013).

The best represented and abundant anuran amphibians that inhabit this area belong to Hylidae, Leptodactylidae, and Bufonidae (Agostini, 2012). The hylids, *P. minuta* Günther and *B. pulchella* (Duméril & Bibron) are small to medium-sized frogs that use aquatic and arboreal habitats, respectively. The leptodactylid *Leptodactylus latrans* Steffen is a large semi-aquatic frog and the bufonid *Rhinella fernandezae* (Gallardo) is a medium sized species with terrestrial and fossorial habits (Cei, 1980).

Specifically, the objectives of this study were (a) to describe the infection pattern of the helminths (at both parasite population and community levels) associated with four native amphibian species, which exploit different life-habits, (b) to explore parasite-host relationships, and (c) to analyse the effects of land use (crops and livestock) on parasite prevalence, abundance and species richness.

MATERIALS AND METHODS

Study area

This study was carried out in nine sampling sites located northeast of the Province of Buenos Aires, Argentina. Five of these sites, which are called "crop" sites (C1-5), represent agroecosystems where intensive agriculture practices are carried out, mainly of soybeans and wheat, where pesticides like glyphosate, endosulfan, chlorpyrifos and cypermethrin are applied (Agostini, 2013). The remaining four, called "livestock" (L1-4), are natural grasslands used for low density dairy livestock pasture activities (Fig. 1).

Collection and examination of amphibians

Sampling took place between 2011 and 2012, distributed in all seasons, and coincided with periods of rain and high amphibian activity. The authorization was provided by the Ministerio de Agroindustria, Buenos Aires Province (Exp. n° 225500-11319/10). Due to their twilight and/or nocturnal habits, hosts were captured manually at night, using the visual encounter surveys technique (Crump & Scott, 1994). Then were transported alive to the laboratory, euthanized with an overdose of 20% benzocaine by tegument impregnation and dissected following the usual parasitological techniques (see Goldberg & Bursey, 2007). Host samples were fixed in 10% formalin and preserved in 70% ethanol. Prior to the necropsy, sex and morphometric data (snout-vent length, weight) for each specimen were recorded.

Parasitological analysis

The parasitological analysis included the examination of tegument, general cavity and respiratory, digestive, urinary and genital systems under a stereoscopic microscope. Helminths were quantified, fixed in cold 5% formaldehyde, and preserved in 70% alcohol. For its identification, nematodes and acanthocephalans were cleared in lactophenol or glycerin-alcohol and studied in temporary preparations. Trematodes and cestodes were compressed slightly between covers and submerged in 96% ethanol for approximately 24 hours. Then they were stained with hydrochloric Carmine diluted in 96% alcohol, dehydrated in an increasing series of alcohols, cleared in xylol, and mounted in Canada balsam in permanent slides. Parasites were examined under light microscopy and the taxonomic study was performed using specific keys (Yamaguti, 1961, 1963; Petrochenko 1971a, b; Anderson, 2000; Khalil *et al*., 1994; Gibson *et al*., 2002; Jones, 2005; Bray *et al*., 2008). The voucher parasite specimens were deposited in the Helminthological Collection of the Museo de La Plata (MLP-He) under the catalog numbers MLP-He 7626-7637 and MLP-He 7680-7690.

Data analyses

To describe the infection patterns at the population level, the prevalence, mean abundance, and mean intensity of infection (followed by their respective standard errors) were calculated following Bush *et al*. (1997). Additionally, the Dispersion Index was calculated as the variance (S^2)/mean ratio (Krebs, 1999). In aggregated distributions the mean number of parasites is smaller than the variance, the ratio has a value higher than 1; in random distributions the value of this relationship is very close to 1 since the variance and the mean are almost equal in value; and in the regular or uniform distribution this ratio is smaller than 1. To describe the infection patterns at the community level, the species richness (S), the diversity index of Shannon-Wiener (H') (Shannon-Weaver, 1949)

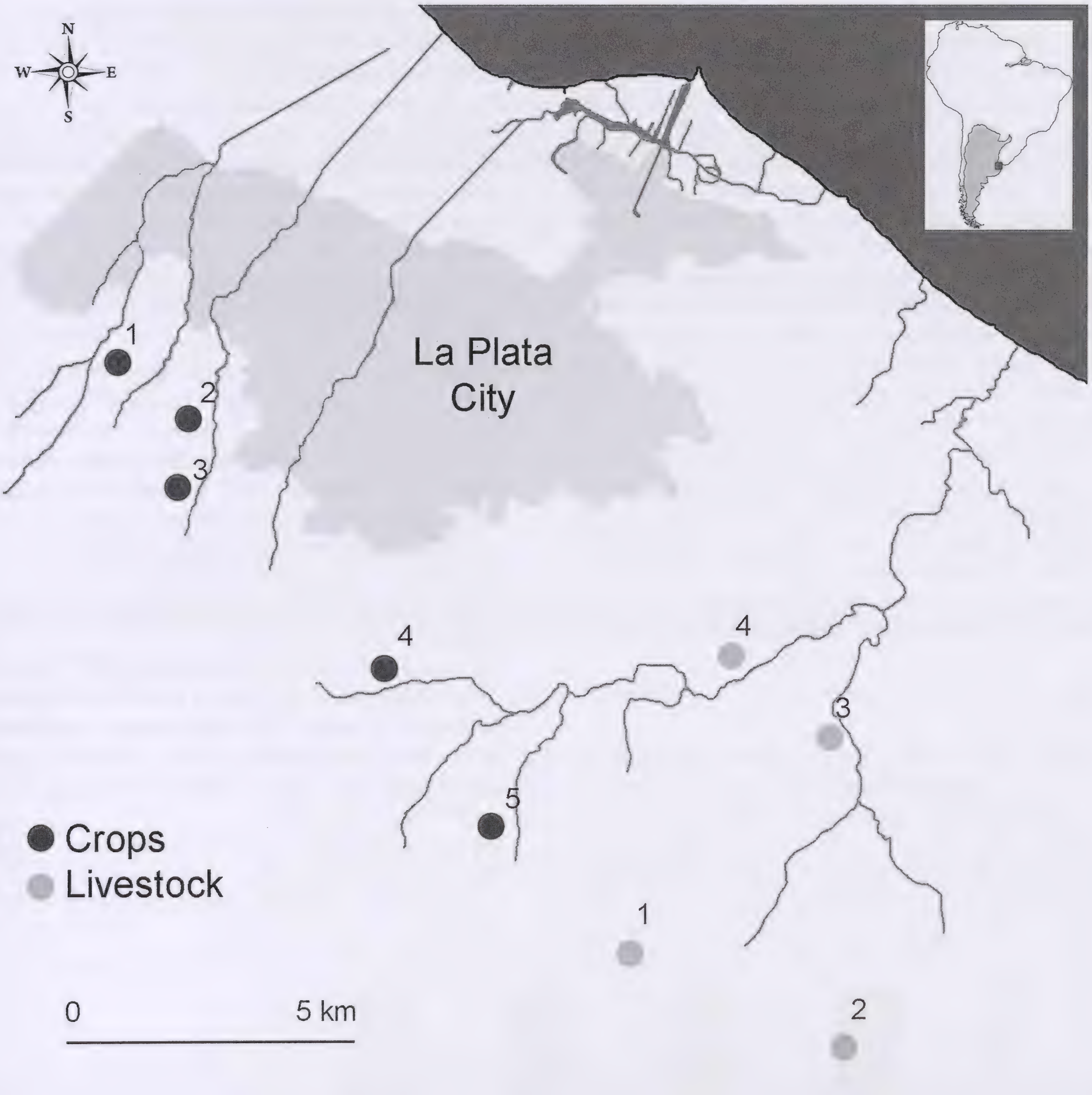


Fig. 1. Study area. C1-5: crop sites, L1- 4: livestock sites (C1: 34°55'13"S; 58°06'33"O; C2: 34°55'54"S; 58°04'29"O; C3: 34°57'36"S; 58°04'57"O; C4: 35°01'42"S; 57°59'44"O; C5: 35°03'06"S; 57°58'35"O; L1: 35°04'27"S; 57°57'23"O; L2: 35°07'46"S; 57°53'11"O; L3: 35°02'22,94"S; 57°48'58,8"O; L4: 35°02'23,2"S; 57°48'58,2"O).

and the Pielou evenness index (J´) (Pielou, 1969) were calculated. Additionally, dominance (d) was obtained using the non-parametric Berger-Parker Index (Berger & Parker, 1970). Dominant, codominant, subordinate, and unsuccessful pioneer species were distinguished according to the Importance index (I) establish by Thul *et al*. (1985). At the infracommunity level, cases of mono or polyspecific infections were recorded. Finally, Jaccard's index for qualitative similarity, based on the presence and absence of helminths, was used to evaluate the similarity of the parasitic infracommunities among the host species. The size and sex of the host were considered to explore parasite-host relationships. We used Mann Whitney U test to test differences in size (snout-vent length, weight) between host males and females. Comparison of two proportions was calculated (Z test) to compare differences in parasite prevalence between host sexes. To prove the existence of significant differences between the abundance and intensity of infection by host sex the Mann Whitney U test was used, and the Spearman correlation when testing these parameters and its association with weight and the snout-ventral length (SVL). We conducted comparison of k proportions ($\chi 2$) to test possible variations related to host sex and size in the abundance of the helminth species that presented prevalence greater than 10%.

To test the effects of land use on the prevalence, abundance, and richness of helminths associated with the amphibian species, generalized linear mixed models (GLMM) with different error distributions were applied (Zuur *et al*., 2009). One model for each response variable was carried out, resulting in a total of three models. Prevalence was analysed employing Binomial distribution, using the term cbind (infected number, uninfected number), while the richness and abundance were analysed with the Poisson distribution and the log link function. The significance of the random effects (sites) was evaluated with a likelihood ratio (LR) test. For all cases, models were constructed with the same variables, considering as fixed effects: land use (crops, livestock) and host species (*B. pulchella*, *L. latrans* and *R. fernandezae*). At the same time, the effect of site variation was controlled considering it as a random effect (nested site in use). The Tukey a posteriori test was used to detect differences between host species. The statistical analyses were carried out with R software, Version 2.15.1 (R Development Core Team 2012) and the GLMM were built with the lme4 package (Bates *et al*., 2012).

RESULTS

A total of 300 hosts were necropsied: 20 specimens of *P. minuta* with prevalence of infection of 50%, 150 *B. pulchella* with prevalence of 35%, 48 *L. latrans* with prevalence of 71%, and 82 *R. fernandezae* with prevalence of 27%. Quantitative descriptors of each helminth species are shown in Table 1. Most of the helminth taxa found in this study are generalists, and were found in the intestinal tract, with the small intestine as the most parasitized organ.

The compound community associated with these four amphibian species comprised twelve helminth taxa: an acanthocephalan species, *Pseudoacanthocephalus* cf. *lutzi* (Hamann, 1891) Arredondo & Gil de Pertierra, 2009 (Echinorhynchidae); six nematode taxa, *Aplectana hylambatis* (Baylis, 1927) Travassos, 1931, *Aplectana* sp., *Cosmocerca parva* Travassos, 1925, *Cosmocercoides* sp. (Cosmocercidae), *Rhabdias elegans* Gutiérrez, 1945 (Rhabdiasidae), and *Schrankiana* sp. (Atractidae); a cestode taxon, *Cylindrotaenia* sp. (Nematotaeniidae) and four trematode taxa *Catadiscus uruguayensis* Freitas & Lent, 1939, *Catadiscus corderoi* Mañé-Garzón, 1958 (Diplodiscidae), *Rauschiella palmipedis* (Lutz, 1928) Sullivan, 1977, Macroderoididae gen. sp. (Macroderoididae). *Pseudoacanthocephalus* cf. *lutzi* and *C. uruguayensis* were the species with the largest host distribution, being found in three host species. For five of the taxa (42%), new parasite-host associations were registered.

Fig. 2 shows the contribution of each group of helminths to the proportion of the total of infected individuals per host species studied. The predominant group is that of the trematodes, with the other groups of helminths contributing to a lesser extent according to the host species and its life habit.

At the community level, similar values of diversity, evenness and dominance were observed in parasite communities, reflecting codominance and an equivalent

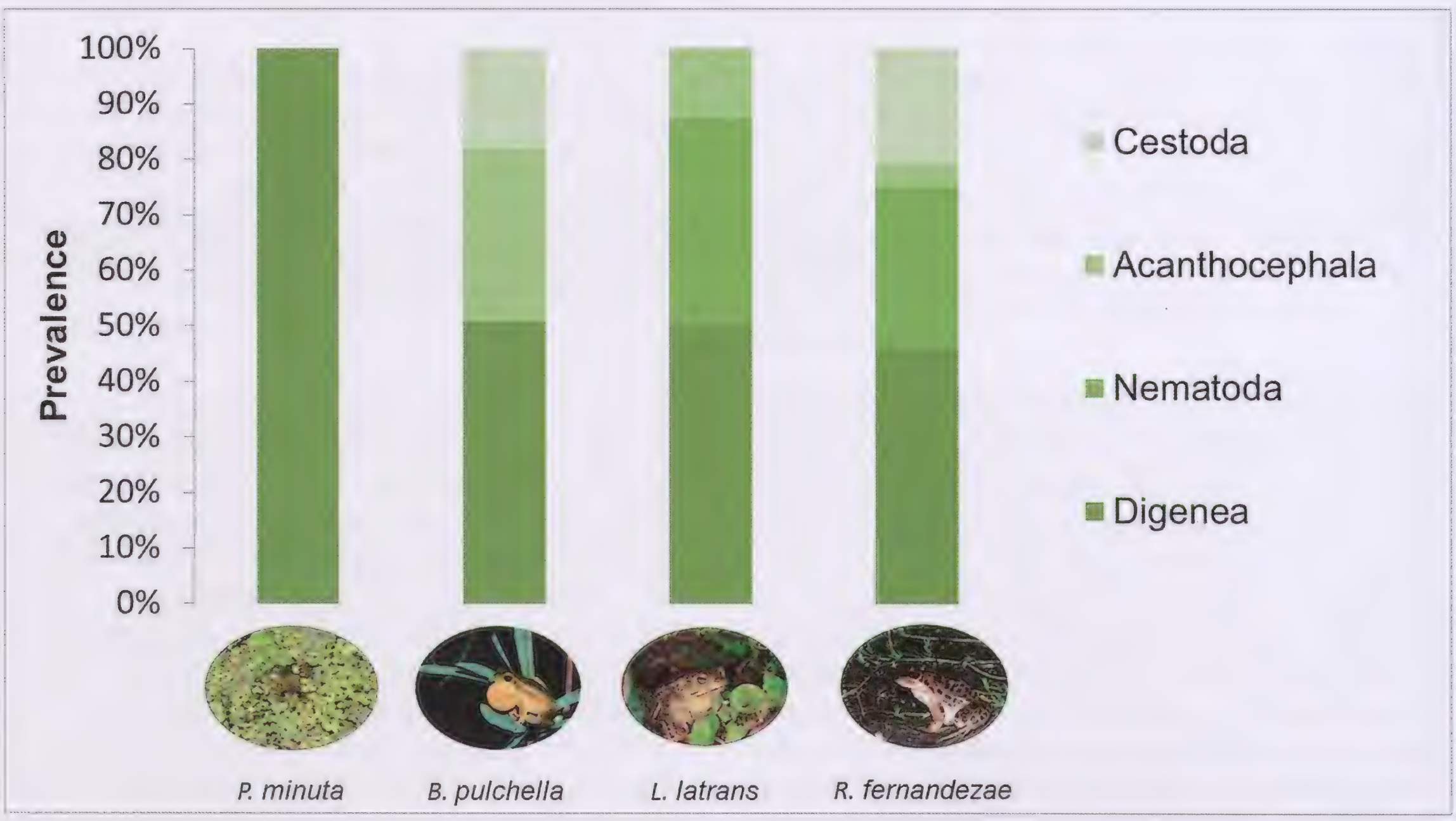


Fig. 2. Contribution of each group of helminths to the proportion of the total of infected individuals for each host species.

Table 1. Prevalence (%), mean intensity (MI)/ mean abundance (MA) ± standard deviation (SD), total number (n) of parasites, infection site, dispersion index (Di), dominance index (d) and Importance index (I) of the helminth taxa found parasitizing four amphibian species from Buenos Aires, Argentina. Li= large intestine, Lu= lungs, Si= small intestine.

Helminth by host	**%**	**n**	**MI ± SD (range)**	**MA ± SD**	**Infection site**			**Di**	**d**	**I**
Pseudis minuta					Lu	Si	Li			
Trematoda										
Catadiscus uruguayensis	50	64	6.4 ± 5.87 (1-15)	3.2 ± 0.29	---	x	x	8.5	0.98	1*
Macroderoididae gen. sp.	5	1	1	0.05	---	---	x	1	0.02	0**
Boana pulchella										
Acanthocephala										
Pseudoacanthocephalus. cf. *lutzi* (new host)	11.3	61	3.59 ± 0.22 (1-12)	0.40 ± 0.02	---	x	x	6.93	0.40	0.41§
Cestoda										
Cylindrotaenia sp. (new host)	6.7	19	1.9 ± 0.087 (1-3)	0.12 ± 0.006	---	x	x	2.15	0.13	0.07§
Trematoda										
C. uruguayensis	15.3	57	2.43 ± 0.06 (1-5)	0.36 ± 0.008	---	x	x	2.79	0.37	0.46§
Rauschiella palmipedis (new host)	6.7	13	1.6 ± 0.07 (1-3)	0.10 ± 0.004	---	x	x	1.78	0.10	0.06§
***Leptodactylus latrans*#**										
Acanthocephala										
P. cf. *lutzi* (new host)	10.4	21	4.2 ± 0.93 (1-12)	0.44 ± 0.09	---	x	x	8.06	0.06	0.06§
Trematoda										
C. uruguayensis	18.8	43	4.78 ± 0.43 (1-13)	0.9 ± 0.08	---	x	x	6.8	0.12	0.22§
R. palmipedis	35.4	45	2.88 ± 0.15 (1-10)	1.02 ± 0.05	---	x	x	4.11	0.14	0.47§
Nematoda										
Aplectana hylambatis	4.2	23	7.5 ± 4.6 (1-14)	0.31 ± 0.19	---	x	x	13.1	0.04	0.02§
Aplectana sp.	2.01	1	1	1	---	x	---	1	0.003	0**
Cosmocerca parva	2.01	23	23	0.47	---	x	x	23	0.06	0.013§
Cosmocercoides latrans (new host)	4.2	159	79.5 ± 35.7 (29-130)	3.31 ± 1.49	---	---	x	110.6	0.46	0.18§
Schrankiana sp.	2.01	25	26	0.54	---	x	x	26	0.075	0.015§
Rhabdias elegans (new host)	10.4	7	1.4 ± 0.18 (1-3)	0.14 ± 0.018	x			1.75	0.02	0.02§
Rhinella fernandezae										
Acanthocephala										
P. cf. *lutzi*	1.2	1	1	0.01	---	x	---	1	0.02	0.003æ
Cestoda										
Cylindrotaenia sp.	6.1	13	2.6 ± 0.36 (1-5)	0.16 ± 0.02	---	x	x	3.5	0.28	0.19§
Trematoda										
Catadiscus corderoi (new host)	13.4	21	1.91 ± 0.02 (1-7)	1.90 ± 0.16	---	x	x	3.26	0.46	0.69§
Nematoda										
C. parva	1.2	4	4	0.04	---	x	x	4	0.08	0.01§
R. elegans (new host)	7.3	7	1.2 ± 0.09 (1-2)	0.07 ± 0.005	x	---	---	1.28	0.13	0.09§

*Dominant species, § codominant species, æ subordinate species, ** unsuccessful pioneer. # Taxonomic helminth data related to *L. latrans* was taken from Draghi *et al*. (2020).

representation of helminth taxa in most cases. The helminth community associated with *P. minuta* was the exception, with a specific richness equal to two. The values of the ecological indices confirmed that in this host the helminth species do not present a similar abundance, and therefore, *C. uruguayensis* is dominant in this community (H′= 0.09 and J'= 0.09). For *B. pulchella* the specific richness was equal to four. The diversity (1.69) and the value of evenness near 1 (J'=0.84) suggests that there is no dominant species in the community. The value of importance confirmed the codominance of parasitic species according to the methodology established by Thul *et al*. (1985) (see Table 1). Regarding the component community of *L. latrans*, the specific richness was equal to nine. The values of the ecological indices suggest that there is an intermediate evenness for the abundance of species (H'= 2.09, J′= 0.65). The species with the highest community dominance index value was the nematode species *Cosmocercoides latrans* (d = 0.46). The values of the importance index indicate that 90% of the helminth species share the dominance of the community. Finally, for *R. fernandezae* the values of the ecological indices (H′= 1.83, J′= 0.78) suggest the existence of one dominant species, and the species with the highest value in terms of dominance index was *C. corderoi* (d = 0.46). On the other hand, following Thul *et al*. (1985) *Cylindrotaenia* sp., *C. corderoi*, *C. parva* and *R. elegans* are codominant species in the community, and *P.* cf. *lutzi* becomes a subordinate and rare species.

At the infracommunity level monospecific infections always predominated. However, cases of multiple infections (two to three helminth species) were recorded in the four amphibians analysed. For *P. minuta* and *B. pulchella* 96% of monospecific infections were observed, and two cases of double parasitosis were recorded in the last one, one digenean-acanthocephalan (*C. uruguyensis* - *P.* cf. *lutzi*) and one between two digeneans species (*C. urugayensis* - *R. palmipedis*), and also two cases of triple parasitosis digenean-acanthocephalan (*C. uruguayensis* - *R. palmipedis* - *P.* cf. *lutzi*). Monospecific infections predominated (79%) in *L. latrans* and in one host, the richness was equal to three, with two species of digeneans and one of nematode (*C. uruguayensis* - *R. palmipedis* - *R. elegans*) coexisting. Finally, for *R. fernandezae* 97.5% of monospecific infections were observed.

In order to establish the values of similarity among the infracommunities of helminths related to the hosts under study, they were compared using the Jaccard coefficient. Fig. 3 shows the similarity matrix obtained and the corresponding dendrogram. According to this, *B. pulchella* and *R. fernandezae* shared a greater number of species (IJ = 0.4).

When considering parasite-host relationships, results indicated that *Pseudis minuta* females were larger and heavier than males (Table 2) with significant differences found (USVL = 2, $p_{0.05}$, 2 = 0.029 and UW = 31, $p_{0.05}$; 2 = 0.029, respectively). Prevalence was higher for females specimens of *P. minuta* (Z = 1.9, p = 0.0024), as well as the values of mean intensity (MI) and mean abundance (MA), but the differences in those cases were not statistically significant (U = 8; $p_{0.05}$; 2 = and U = 7; $p_{0.05}$; 2 = 1, respectively) (Table 3). Additionally, the abundance of *C. uruguayensis* (prevalence > 10%) correlated only with the size of females (rs= 1.000, p < 0.005).

For *B. pulchella* specimens, females were significantly larger than males (USVL = 2336, $p_{0.05}$, 2 <0.0001 and UW = 722, $p_{0.05}$, 2 <0.0001). Although from a descriptive approach the prevalence was slightly higher in females (Table 4), no significant difference was found between sexes (Z = 0.27, p = 0.78). Differences were statistically significant for MI and MA (U = 329; $p_{0.05}$, 2 = 0 and U = 344; $p_{0.05}$; 2 ≤ 0.0001, respectively). There was no relationship between the parasite abundance of species that presented a prevalence greater than 10% (*P.* cf. *lutzi* and *C. uruguayensis*), and the host's body parameters (considering the total of the hosts and separated by sex). On the other hand, males of *L. latrans* were more robust (UW = 100, $p_{0.05}$, 2 = 0.004). There was no significant difference in prevalence between host sexes (Z = 0.25, p = 0.802). Similarly, MA and MI that were higher in males, did not present statistically significant differences (U = 105, $p_{0.05}$, 2 = 0.41 and U = 103, $p_{0.05}$, 2 = 0.47, respectively) (Table 3). Of the species with prevalence greater than 10%, *C. uruguayensis* was the only one that presented a negative, high, and significant correlation with weight when considering the total number of hosts (r_s= - 0.809, p < 0.005).

Finally, males of *R. fernandezae* were larger and heavier

	1	2	3	4
1- P. minuta	1	0.2	0.1	0
2- B. pulchella	0.2	1	0.3	0.4
3- L. latrans	0.3	0.3	1	0.27
4- R. fernandezae	0	0.4	0.27	1

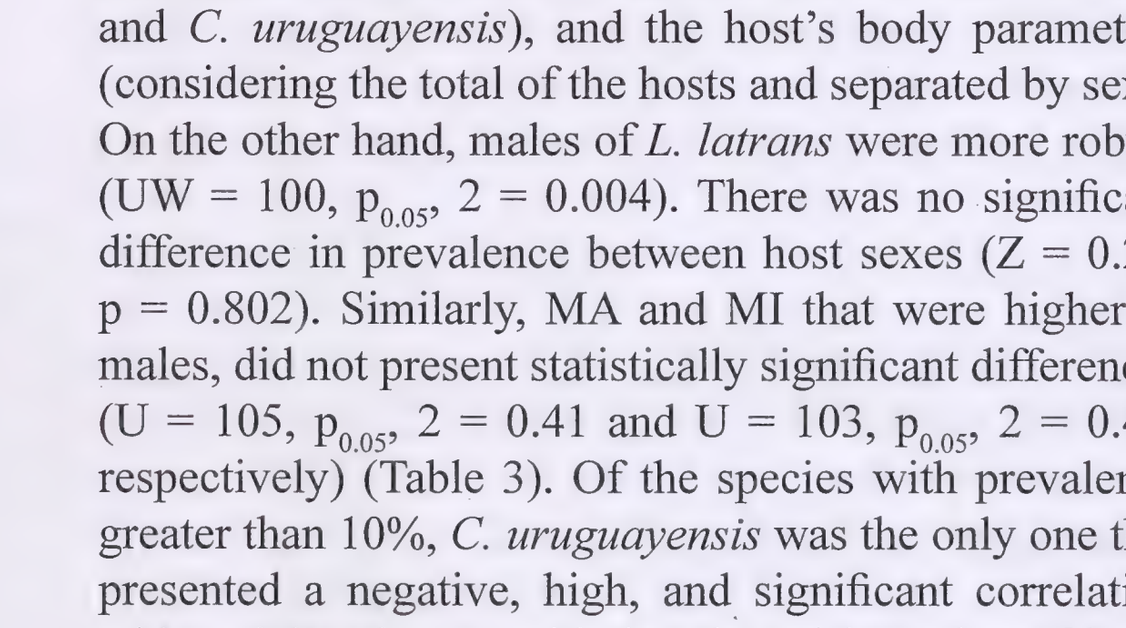


Fig. 3. Similarity matrix and dendrogram.

than females (USVL = 805; $p_{0.05}$; 2 <0.0001 and weight UW = 769; $p_{0.05}$; 2 <0.0001) (Table 3). From a descriptive perspective, both the prevalence of infection and the total number of helminths were slightly higher for males of *R. fernandezae*, but these differences were not statistically significant (Z = -0.09, p = 0.92). In contrast, values of MI and MA were higher in females (U = 6, $P_{0.05}$, 2 = 0.011) (Table 3). The abundance of the only species that presented a prevalence greater than 10% (*C. corderoi*) did not correlate with the host's body parameters.

Table 4 shows the values of Prevalence (P) and abundance (MA) of the helminth taxa for three host species (*B. pulchella*, *L. latrans* and *R. fernandezae*), distinguished by sampling site. The acanthocephalan *P.* cf. *lutzi* was found in the three hosts. Its maximum prevalence value was 56% parasitizing *B. pulchella* on the L2 site. It should be noted that as was not found in any of the crop sites, *P. minuta* was excluded from the GLMM analysis.

According to the GLMM, no significant effect of the sampling sites was detected, so models were corrected. In contrast, LR test showed significant random effects of sex for the models testing differences in helminths prevalence (χ^2= 4.06, df =1, p= 0.04) and abundance (χ^2=

Table 2. Sample size (n), snout-ventral length (SVL; mm) and weight (W; g) for four amphibian species from Buenos Aires, Argentina. Mann Whitney U test, significant values (p< 0.05) in bold.

	Sex	n	SVL, mean ± SD (min-max)	W, mean ±SD (min-max)
P. minuta	♀♀	3	**41.58 ± 6.27 (35-47.5)**	**8.38 ± 3.09 (5-11.1)**
	♂♂	11	34.28 ± 4.5 (29.5- 36.6)	4.5 ± 0.5 (3.8-6)
	§§	6	32.9 ± 3.34 (29.5- 38.5)	4.26 ± 0.95 (2.8-5.3)
B. pulchella	♀♀	26	**46.62 ± 45.24 (33.61- 54.89)**	**5.91 ± 2.18 (2.3-10.67)**
	♂♂	114	41.81 ± 3.5 (34-50)	4.11 ± 1.28 (1.96-11.5)
	§§	10	42.02 ± 2.52 (37.5-45.8)	3.81 ± 0.76 (2.11-4.95)
L. latrans	♀♀	15	78.37 ± 8.22 (61.64-93.03)	42.28 ± 15.17 (27.45-77.32)
	♂♂	23	83.31 ± 1.81 (58.62-104.06)	**69.20 ± 32.08 (23.8-143.8)**
	§§	10	81 ± 11.77 (56.15-94)	59.58 ± 39.25 (17-97)
R. fernandezae	♀♀	18	50.53 ± 8.55 (13.3-61.8)	14.47 ± 9.25 (2.88-61.77)
	♂♂	56	**60.56 ± 7.07 (41.34-69.7)**	**21.57 ± 6.77 (7.6-32.15)**
	§§	8	56.5 ± 7.5 (46.42-64.5)	17.45 ± 6.38 (10.32-26.74)

§§ = not sexually differentiated.

Table 3. Indicators of parasite infection by sex of the host. Sample size (n), Prevalence (%), Mean Intensity (MI)/ Mean Abundance (MA) ± standard deviation (SD), and total number (*n*) of parasites. Z test (%) and Mann Whitney U test (MI and MA) significant values (p< 0.05) in bold.

Host Species	Sex	n	%	*n*	MI ± SD (range)	MA ± SD
P. minuta	♀♀	3	**100**	22	7.33 ± 2.34 (1-15)	7.33 ± 2.34
	♂♂	11	45.45	34	6.8 ± 1.33 (1-15)	3.09 ± 0.6
	§§	6	33.33	8	4 ± 2.12 (1-7)	1.33 ± 0.7
B. pulchella	♀♀	26	36.7	24	**2.4± 0.18 (1-7)**	**0.9 ± 0.07**
	♂♂	114	33.3	115	3.02 ± 0.08 (1-12)	1 ± 0.03
	§§	10	50	11	2.2 ± 0.22 (1-4)	1.1 ± 0.09
L. latrans	♀♀	15	73.3	55	5 ± 0.34 (1-12)	3.66 ± 0.26
	♂♂	23	69.56	252	15.75 ± 2 (1-130)	10.95 ± 1.4
	§§	10	50	40	8 ± 0.93 (3-15)	4 ± 0.47
R. fernandezae	♀♀	18	22.2	12	**3 ± 1 (1-9)**	**0.66 ± 0.22**
	♂♂	56	26.78	26	1.71± 0.084(1-5)	0.46 ± 0.023
	§§	8	37.5	7	2.33 ± 0.5 (1-4)	0.87 ± 0.19

§§ = not sexually differentiated.

Table 4. Parasites per host and sampling site. Sample size (n), Prevalence (%), Mean Abundance (MA) ± standard deviation (SD), C=crop sites, L= livestock sites.

Host	Helminth	Site	n	(%)	MA±SD
B. pulchella	*Cylindrotaenia* sp.	C1	5	40	1±0.14
		C4	4	8	0.16
		L1	1	3.84	0.038
		C3	5	13.63	0.22±0.05
		C2	3	14.2	0.42
C. uruguayensis		C4	3	8	0.12±0.02
		L2	8	21.42	0.57±0.1
		L3	21	34.78	0.91±0.07
		L1	15	26.92	0.57±0.04
		C3	8	13.63	0.36±0.06
		L4	1	5.88	0.06
P. cf. *lutzi*		C4	1	4	0.04
		L3	38	56	1.65±0.13
		L4	13	11.76	0.76±0.37
		C5	9	9.09	0.81
R. palmipedis		C4	1	4	0.04
		L2	2	7.14	0.14
		L3	7	13.04	0.3±0.045
		C3	1	4.54	0.045
		L4	1	5.88	0.058
		C5	2	18.18	0.18
L. latrans	*P.* cf. *lutzi*	L3	21	5	2.62±1.06
	C. uruguayensis	L2	17	66.66	5.66±2.12
		L3	1	12.5	0.125
		L4	1	20	0.2
		C2	1	14.28	0.14
		C3	23	20	1.15±0.063
	R. palmipedis	C4	1	50	0.5
		L3	2	25	0.25
		C3	5	40	1±0.14
		C2	11	28.6	1.57±0.3
		L4	26	45	1.3±0.15
		C5	4	50	2
	A. hylambatis	L4	15	10	0.75±0.45
	Aplectana sp.	C1	1	100	1
	C. parva	C5	29	50	14.5
	Cosmocercoides latrans	L4	29	5	1.45
		C2	130	14.3	18.5
	Schrankiana sp.	L4	25	5	1.2
	R. elegans	C3	3	20	0.6
		L4	4	20	0.15

Table 4 (continued)

Host	Helminth	Site	n	(%)	MA±SD
R. fernandezae	*P.* cf. *lutzi*	L4	1	6.25	0.0625
	Cylindrotaenia sp.	C4	5	3.84	0.19
		L1	1	12.5	0.05
		C3	4	7.14	0.285
		L4	3	12.5	0.18±0.044
	C. corderoi	C4	7	19.23	0.26±0.032
		C3	11	28.57	0.78±0.035
		L4	3	12.5	0.1875±0.044
	C. parva	C2	4	9.09	0.36
	R. elegans	C4	2	7.69	0.077
		L4	2	12.5	0.125
		C3	2	7.14	0.142

4.49, df= 1, p= 0.03). The helminths prevalence did not vary significantly according to land use (Z = -0.71, p = 0.09). However, they were higher for the livestock sites in the three host species, standing out in L1 and L2 sites (Prevalence = 75% and 42%, respectively). Likewise, parasite prevalence was different across host species (Z = 5.42, p <0.05), being higher for *L. latrans* (Tukey a posteriori test p <0.05) (Fig. 4A). When the effect of land use on helminth abundance was explored, the analyses showed that the highest abundances were found in crop sites (Z = 3.12, p <0.05). In addition, abundances varied among host species (Z = -4.21, p <0.05), with *L. latrans* presenting the highest values (Fig. 4B). The analyses on the infracommunities helminth richness showed a significant effect of land use (Z = 4.40, p <0.05) with hosts from the livestock sites presenting the highest values. In turn, richness varied among host species (Z = -4.93, p <0.05), again with *L. latrans* specimens presenting the highest values (Fig. 4C).

DISCUSSION

In the present study, a marked relationship between the habit preference of the hosts and their helminth communities was observed. Digeneans predominated in aquatic and arboreal amphibians (Hylids). On the other hand, nematodes with a direct life cycle were present in semi-aquatic and terrestrial amphibians (Leptodactylids and Bufonids). However, trematodes always dominated in numbers among the parasite communities, showing the close relationship of this group of hosts with the aquatic environment.

Aho (1990) established a trend, positioning the species according to their habitat preference in a terrestrial-aquatic environmental transition. In this trend, species of semi-aquatic amphibians possess the highest species richness of helminths (both at the population level and per individual host); terrestrial and aquatic species tend to have intermediate and similar values, while those with arboreal or fossorial habits have a lower helminth species richness. According to this and other authors, the type of diet is an additional factor that can lead to differences in the helminth communities of amphibian hosts and influence its development, (generalists vs. specialists) (Poulin, 2007; Poulin & Morand, 2004). In the present study, the helminth communities of *P. minuta* and *B. pulchella* were composed mainly of helminths with aquatic and indirect life cycles, with dominance of those whose transmission is achieved by a trophic route (e.g.: *C. uruguayensis*, *Cylindrotaenia* sp.).

In comparison with other species of *Pseudis* previously studied (Kehr & Hamann, 2003; Campião *et al*., 2010), the specific richness for *P. minuta* in the present study was extremely low, with only one species of digenean (*C. uruguayensis*) in the adult stage. *Pseudis minuta* was assumed abundant in the study area, but was found only in two livestock sites, and was completely absent from the crop sites. According to Agostini (2013) this can be related to the effects of pesticides as well as the presence of different stress factors in these ecosystems. Characteristics of this host as its low population density, small body size and other hosts with which it interacts could be affecting its parasitic communities (Price, 1990). *Boana pulchella* normally lives in the axillary pods of the long leaves of marsh plants belonging to the genus *Eryngium* sp. (Apiaceae), hunting and feeding mainly on diptera (Langone, 1994). The arboreal and climbing habit of this species could reduce the chances of infection by directly transmitted parasites (from the soil or the aquatic environment), causing the occurrence of trophically transmitted helminths through the ingestion of infected hosts, free infective stages (cercariae) or cystic (metacercariae). As was found by Hamann *et*

al. (2009) and Campião *et al*. (2015) for climbing amphibians, the predominant group of helminths was that of trematodes, with two species: *C. uruguayensis* and *R. palmipedis*. As for the species with the highest prevalence of infection, *Pseudoacanthocephalus* cf. *lutzi* and *C. uruguayensis*, both have an indirect life cycle that need an aquatic intermediate host to be complete and are transmitted by trophic route. At least one species of *Pseudoacanthocephalus* has as intermediate host terrestrial isopods (Nakao, 2016), arthropods in close relationship with humid environments. There were often isopods in the stomach and intestinal contents of *B. pulchella* in our study and these arthropods have been cited as dietary components in other populations of *B. pulchella* in Argentina (Antoniazzi *et al*., 2013) and Uruguay (Maneyro *et al*., 2004). In addition, it is presumed that for the *Cylindrotaenia* species (nematotaenid cestodes with direct life cycle) infection also occurs by trophic route, but in this case by the ingestion of proglottids with embryonated eggs (Stumpf, 1981/1982; Brooks *et al*., 2006). With respect to *R. palmipedis*, a digenean with an indirect and aquatic life cycle, it presented low prevalence (6.7%) and this could also be related with the habit preference of *B. pulchella*. The terrestrial habitat and the mobility of *R. fernandezae* associated with the active search for prey (mainly ants), can favour the active penetration of infective nematode larvae (*C. parva*, *R. elegans*), resulting in a more diverse community of parasites, where the four groups of helminths were represented. Previous reports in South America indicate that amphibian helminth communities belonging to *Rhinella* are mostly composed of nematode species (Hamann *et al*., 2013, 2014a). For *R. fernandezae* populations, this dominance of nematodes with direct life cycle is due to the terrestrial habits of the host since the adult frogs lives in burrows and only leaves to feed (Hamman *et al*., 2012). In the present study, the helminth community presented a richness score of five. Trematodes were the best represented group numerically, with *C. corderoi* (aquatic life cycle) as the dominant species (d = 0.46). *Cylindrotaenia* sp. also has an aquatic life cycle, but in this case, it is assumed to be direct; and the nematode species *C. parva* and *R. elegans* are characterized by presenting monoxenous life cycles and inhabiting both wet and dry soils with infection occurring through penetration by the larval stage through the skin of the host (Anderson, 2000). The low prevalence of nematodes found in *R. fernandezae* may be because adults of this toad species possess a thick tegument, which could be a limiting factor for the penetration of infective larvae.

Finally, the high species richness of helminths present in *L. latrans* would correspond not only to their habitat preference but also to its larger size, which would provide a greater colonization surface, and a greater energy requirement, translated into a greater food intake (Duré & Kehr, 1999; Hamman *et al*., 2006a). *Leptodactylus latrans* is a generalist predator, which uses an intermediate strategy between active foraging and what is known as "sit and wait". Their diet consists of earthworms, snails, spiders, insects, and other amphibians

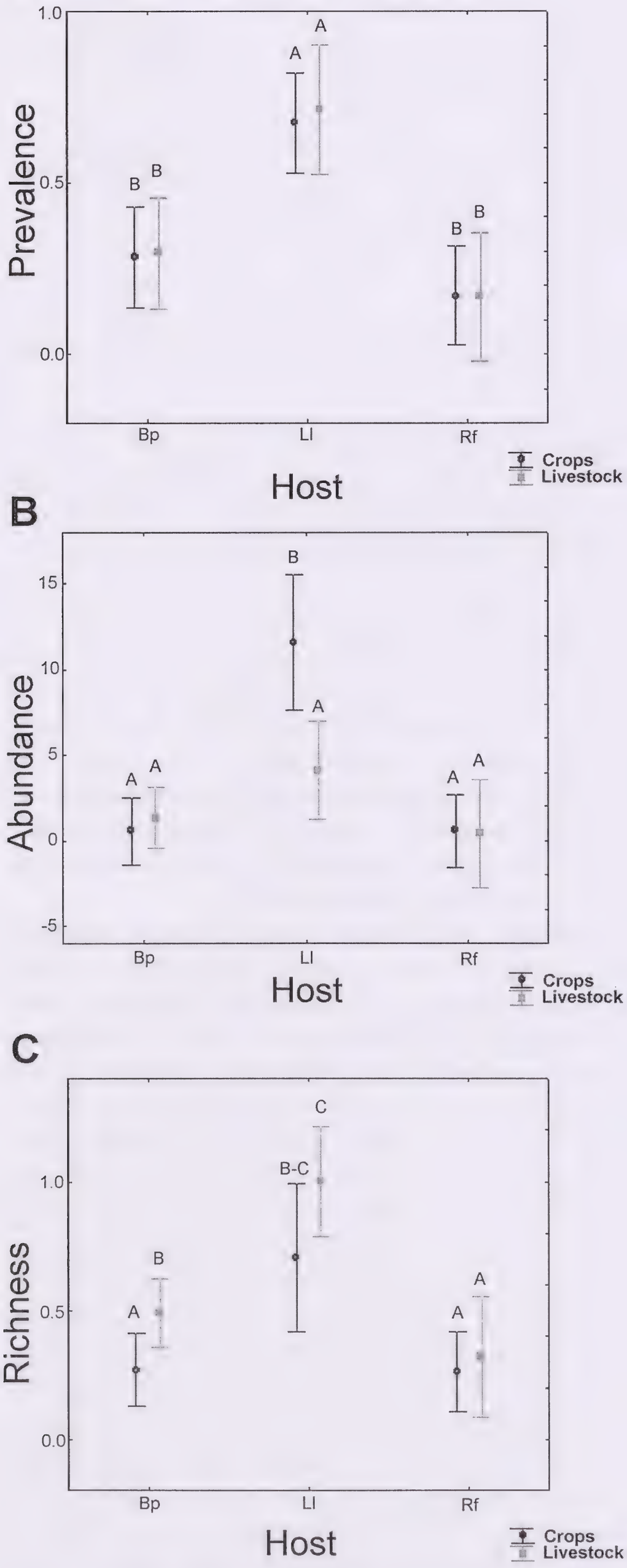


Fig. 4. Helminth prevalence (A), abundance (B) and richness (C) at infracommunity level, in relation to land use and host species. *B. pulchella* (Bp), *L. latrans* (Ll), *R. fernandezae* (Rf).

(Langone, 1994). According to the present study, it can be confirmed that it feeds both on land (*P.* cf. *lutzi*) and in the aquatic environment (*C. uruguayensis*). Habitat and mobility (water-ground) of the host, associated with the search for prey, could favour the penetration of the infective stages of the helminths, resulting in a richer and more diverse parasitic community (Hamann *et al.*, 2013b). These data agree with those obtained by different authors for populations of *L. latrans* (Vicente & Santos, 1976; Stumpf, 1981/1982; Goldberg *et al.*, 2009; Toledo *et al.*, 2015) and are similar to those reported for other leptodactylids in Argentina (Hamann *et al.*, 2006a, b, 2012). *Leptodactylus latrans* has a wide range of associated helminths, characteristic of both aquatic and terrestrial environments.

When comparing the parasite infracommunities associated with the four amphibian hosts here studied, *B. pulchella* and *R. fernandezae* shared a greater number of species and presented, therefore, similar parasite communities. In contrast, *P. minuta* and *R. fernandezae*, amphibians located at the ends of the water-land continuum, did not present species in common.

Sexual dimorphism in size may influence the intensity of infection or the richness of parasite species (McAlpine, 1997). A larger body would provide more area for the colonization of parasites and would allow a higher probability of cercariae penetration (Hamann *et al.*, 2010). In this sense, there was a correlation between the parasitic abundance of *C. uruguayensis* and the body length values of *P. minuta* females. In addition, prevalence was higher for females. Cercariae of *Catadiscus* species emerge from the gastropod that acts as an intermediate host, encyst in different substrates (aquatic vegetation and other substrates) and are ingested by the definitive host in which they mature (Ostrowski de Núñez, 1978/1979). Zank *et al.* (2010) observed a very marked location for males of *P. minuta*, they are found in more remote and deeper places away from the shore of the water body. Meanwhile females remain in places close to shore. These differences in the use of microhabitats were also observed for the population of *P. minuta* from the sample area studied. The spatial distribution of freshwater gastropods that could act as intermediate hosts for digeneans, like planorbids, is mostly aggregated. Also, these gastropods are littoral mollusks associated with vegetation (Gutiérrez Gregoric *et al.*, 2006). Cercariae that emerge are short-lived (Esch *et al.*, 2002), encysting in the nearby vegetation or on some substrate. Because they are closer to shore, females of *P. minuta* would have a higher probability of encountering the infective stages of the parasites, and in addition, they have a larger body size that represents a greater colonization surface.

A similar situation was observed for *R. fernandezae*, no significant differences were found in relation to the prevalence between sexes. Nevertheless, in parasitized females the intensity and abundance of infection was higher. This could be that the encounter probability is higher for females due to variability in behaviour or their habitat selection; or could also be inferred that the probability of encountering with infective stages was similar for males and females, but in the latter, perhaps due to issues related to their feeding and / or time in water or land, the infection was more intense. However, when relating size and weight to infection indicators only for infected females, no correlation was observed: females of larger size and weight were not more parasitized. This confirmed that helminths presented an aggregate distribution in the host population.

For *B. pulchella*, the situation was the opposite. Although females are larger, values corresponding to the number of parasites, the mean intensity and the average abundance of infection were slightly higher for males. These differences could be attributed to a differential behaviour between sexes, either in relation to the permanence in the water body or to their prey items.

Lastly, for *L. latrans* the parasite prevalence was similar between males and females, so the probability of encountering with infective stages of helminths would seem to be equal between sexes. In some amphibian hosts, the body size has been related to the richness of helminths (Hamann & Kehr, 1998; Bolek & Coggins, 2003; Hamann *et al.*, 2006b), but this was not this case, since the host's body parameters did not relate to parasitic indicators of infection. The only helminth species whose abundance correlated with the weight of the hosts was *C. uruguayensis*, and according to its life cycle, it could be assumed that a larger host ingests larger amounts of food (Duré & Kehr, 1999).

Beyond the intrinsic characteristics of each species, hosts that share the same location, even those belonging to different genera or species, can share helminth taxa because they are exposed to the same ecological conditions (Aho, 1990). The development of agricultural activities is identified as one of the main causes that contribute to the loss of biodiversity, not only due to the reduction and fragmentation of the habitat, but also because of the agrochemicals used (Agostini, 2013). In our study the prevalence of infection in the host species that were present in both types of land uses (crops and livestock) was not related to land use. Should the prevalences be determined by the probability of parasite-host encounter, we can assume that the occurrence and abundance of larval stages and intermediate hosts in both types of sites is similar.

In general, parasite abundance seems to be negatively affected by environmental disturbances (Hamann *et al.*, 2006a; Koprivnikar *et al.*, 2006; McKenzie, 2007; Hartson *et al.*, 2011). In the present study, it varied significantly according to land use, with abundance being higher for crop agroecosystems as compared to livestock sites. This could be related to the high abundances observed for the cosmocercids nematodes with direct life cycle (*A. hylambatis*, *Aplectana* sp., *C. parva*, *C. latrans*) which also presented higher prevalences at the crop sites.

Within their hosts, nematodes present an aggregated distribution, most infected hosts have few parasites and a few hosts have many parasites (Anderson & May, 1978). For these parasites, with direct and monoxenous life cycle, the interactions with the different stressors are less predictable. If the stressor has a strong and negative effect on the hosts defences, it will intensify the impact of the parasites (Lafferty & Kuris, 1999; Johnson & Chase, 2004; Johnson & Sutherland, 2003; Johnson *et al*., 2007), and this could be happening in crop sites.

The species richness of helminths at infracommunity level, on the other hand, was significantly higher in amphibian specimens collected at livestock sites. The presence of a greater variety of parasitic species may correspond to a healthier ecosystem (Marcogliese, 2005) since a community rich in parasites should reflect the number of host species available (Hudson *et al*., 2006). The amphibian communities in the livestock sites are richer and the populations of the three host species more abundant (Agostini, 2013) and this could be related to the greater richness of helminths in these sites.

Finally, the three variables studied were significantly related to the host species. *Leptodactylus latrans* presented the highest prevalence, abundance, and species richness at infracommunity level. As discussed above, characteristics of this host such as its size, habit (semi-aquatic) and diet (generalist) were related to its associated parasite community, and these results agree with previous ecological studies carried out on the helminth fauna of this host species in the Neotropical region (Toledo *et al*., 2015).

According to Campião *et al*. (2015) an average of four studies is needed to describe 50% of the parasite richness in anuran amphibians and only 22% of South American anurans presently match this criterion. The present study is a contribution to the description of helminth diversity in amphibians and is the first involving ecological aspects of the parasite groups for populations of *P. minuta* and *B. pulchella* throughout their distribution area, and the first one for *L. latrans* in Argentina. It also represents the first approach to communities of helminths associated with anurans that inhabit agroecosytems of the Pampean Region.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to Micaela Medina, Giselle Mangini, Dante Ciai, Matías Rosales, Micaela Santos and Sabrina Parisi for their assistance in the field. This study was partially funded by CREOI Foundation and Neotropical Grassland Conservancy.

REFERENCES

Agostini M.G. 2012. Ranas y sapos del fondo de tu casa. Anfibios de agroecosistemas de La Plata y alrededores. *EDULP, La Plata*, 48 pp.

Agostini M.G. 2013. Ecotoxicología de anfibios en agroecosistemas del noreste de la región Pampeana. Dissertation Thesis, Universidad Nacional de La Plata, 150 pp.

Agostini M.G., Burrowes P.A. 2015. Infection patterns of the chytrid fungus, *Batrachochytrium dendrobatidis*, on anuran assemblages in agro-ecosystems from Buenos Aires Province, Argentina. *Phyllomedusa* 14(2):113-126.

Aho J.M. 1990). Helminth communities of amphibians and reptiles: Comparatives approaches to understanding patterns and processes. *In:* Esch G., Bush A., Aho J. (eds.), Parasite communities: Patterns and processes. *Chapman and Hall, New York*, pp. 157-196.

Anderson R.C. 2000. Nematode Parasites of Vertebrates: Their Development and Transmission. *CAB International, Oxford*, 672 pp.

Anderson R.C., May R.M. 1978. Regulation and stability of host-parasite population interactions. I. Regulatory processes. *Journal of Animal Ecology* 47: 219-247.

Antoniazzi C.E., López J.A., Duré M., Falico D.A. 2013. Alimentación de dos especies de anfibios (Anura: Hylidae) en la estación de bajas temperaturas y su relación con la acumulación de energía en Santa Fe, Argentina. *Revista de biología tropical* 61(2): 875-886.

Arredondo N.J., Gil de Pertierra A.A. 2009. *Pseudoacanthocephalus lutzi* (Hamann, 1891) comb. n. (Acanthocephala: Echinorhynchidae) for *Acanthocephalus lutzi* (Hamann, 1891), parasite of South American amphibians. *Folia Parasitológica* 56: 295-304.

Bates D., Maechler M., Bolker B. 2012. lme4: Linear mixed-effects models using S4 classes. Disponible en: http://CRAN.R-project.org/package=lme4 (R package version 0.999999-0). Accessed June 2019.

Berger W.H., Parker. F.L. 1970. Diversity of planktonic foraminifera in deep-sea sediments. *Science* 168:1345-134.

Bolek M.G., Coggins J.R. 2003. Helminth community structure of sympatric eastern American toad, *Bufo americanus americanus*, northern leopard frog, *Rana pipiens*, and blue-spotted salamander, *Ambystoma laterale*, from south-eastern Wisconsin. *Journal of Parasitology* 89(4): 673-80.

Bray R.A., Gibson D.I., Jones A. (eds). 2008. Keys to the Trematoda. Vol. 3. *CABI Publishing and The Natural History Museum, Wallindford,* 848 pp.

Brooks D.R., León-Règagnon V., McLennan D.A., Zelmer D. 2006. Ecological fitting as a determinant of the community structure of platyhelminth parasites of anurans. *Ecology* 87: 576-585.

Bush A.O., Lafferty K.D., Lotz J.M., Shostak A.W. 1997. Parasitology meets ecology on its own terms: Margolis *et al*. revisited. *Journal of Parasitology* 83: 575-583.

Campião K.M., Silva R.J.d, Ferreira V.L. 2010. Helminth component community of the paradoxal frog *Pseudis platensis* Gallardo, 1961 (Anura: Hylidae) from South-eastern Pantanal, Brazil. *Parasitology Research* 106(3): 747-751.

Campião K.M., Ribas A.C.d.A., Morais D.H., Silva R.J.d., Tavares L.E.R. 2015. How many parasites species a frog might have? Determinants of parasite diversity in South american anurans. *PLos ONE* 10(10): e014057.doi: 10.1371/journal.pone.0140577.

Cei J.M. 1980. Amphibians of Argentina. Monography 2, *Monitore Zoologico Italiano (n.s.)*, 609 pp.

Crump M.L., Scott N.J. 1994. Visual encounter surveys. *In:* Heyer W., Donnelley D.A., McDiarmid R.A., Hayec L.C., Foster M.C. (eds), Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians. *Smithsonian Institution Press, Washington,* pp. 84-92.

Draghi R., Drago F.B., Lunaschi L.I. (2020). A new species of *Cosmocercoides* (Nematoda; Cosmocercidae) and other helminths in *Leptodactylus latrans* (Anura; Leptodactylidae) from Argentina. *Anais da Academia Brasileira de Ciências:* 92: e20180499. DOI 10.1590/0001-3765202020180499.

Duré M.I., Kehr L.A. 1999. Explotación Diferencial de los Recursos Tróficos en Cuatro Especies de Bufonidos del Nordeste Argentino. *Actas Ciencia y* Técnica UNNE 6: 17-20.

Esch G.W., Barger M.A., Fellis J.K. 2002. The transmission of digenetic trematodes: style, elegance, complexity. *Integrative and Comparative Biology* 42: 304-312.

Freitas J.F.T., Lent H. 1939. Revisão do gênero *Catadiscus* Cohn, 1904 (Trematoda, Paramphistomoidea). *Boletim Biologico* 4: 305-315.

Gibson D.I., Jones A., Bray R.A. 2002. Keys to the Trematoda. Vol. 1. *CABI Publishing, Wallingford,* 544 pp.

Goldberg S.R., Bursey C.R. 2007. Helminths of two species of frogs, *Lithobates taylori* and *Lithobates vaillanti* (Ranidae), from Costa Rica. *Caribbean Journal of Science* 43: 65-72.

Goldberg S.R., Bursey C.R., Caldwell J.P., Shepard D.B. 2009. Gastrointestinal helminths of six sympatric species of *Leptodactylus* from Tocantins state, Brazil. *Comparative Parasitology* 76: 258-266.

Gutiérrez R.O. 1945. Contribución al conocimiento de los nemátodos parásitos de anfibios argentinos. Dissertation Thesis, Universidad Nacional de La Plata, 37 pp.

Gutiérrez Gregoric D.E., Núñez V., Rumi A., Roche M.A. 2006. Freshwater gastropods from Del Plata Basin, Argentina. Checklist and new locality records. *Comunicaciones de la Sociedad Malacológica del Uruguay* 9 (89): 51-60.

Hamann M.I., Kehr A.I. 1998. Variación espacio temporal en infrapoblaciones de helmintos y su relación con las fluctuaciones poblacionales de *Hyla nana* (Anura, Hylidae). *Cuadernos de herpetología* 12: 23-33.

Hamann M.I., Kehr A.I., González C.E. 2006a. Species affinity and infracommunity ordination of helminths of *Leptodactylus chaquensis* (Anura: Leptodactylidae) in two contrasting environments from Northeastern Argentina. *Journal of Parasitology* 92: 1171-1179.

Hamann M.I., Kehr A.I., González C.E. 2006b. Helminth community structure of the oven frog *Leptodactylus latinasus* (Anura, Leptodactylidae) from Corrientes, Argentina. *Acta Parasitológica* 51(4): 294-299.

Hamann M.I., Kehr A.I., González C.E. 2010. Helminth community structure of *Scinax nasicus* (Anura: Hylidae) from a South American subtropical area. *Diseases of Aquatic Organisms* 93: 71-82.

Hamann M.I., Kehr A.I., González C.E. 2012. Community structure of helminth parasites of *Leptodactylus bufonius* (Anura: Leptodactylidae) from Northeastern Argentina. *Zoological Studies* 51: 1454-1463.

Hamann M.I., Kehr A.I., González C.E. 2013. Helminth communities in the burrowing toad, *Rhinella fernandezae*, from Northeastern Argentina. *Biología* 68(6): 1155-1162.

Hamann M.I., Kehr A.I., González C.E. 2014a. Erratum to "Helminth communities in the burrowing toad, *Rhinella fernandezae*, from Northeastern Argentina" by Monika Inés Hamann, Arturo Ignacio Kehr and Cynthya Elizabeth González. *Biologia* 69(2): 260-261.

Hamann M.I., Kehr A.I., González C.E. 2014b. Helminth community structure in the Argentinean bufonid *Melanophryniscus klappenbachi*: importance of habitat use and season. *Parasitology Research* 113(10): 3639-3649.

Hamann M.I., Kehr A.I., González C.E., Schaefer E.F. 2009. Parasite and reproductive features of *Scinax nasicus* (Anura: Hylidae) from a South American Subtropical area. *Interciencia* 34(3): 214-218.

Hartson R.B., Orlofske S.A., Melin V.E., Dillon R.T. Jr, Johnson P.T.J. 2011. Land use and wetland spatial position jointly determine amphibian parasite communities. *Ecohealth* 8: 485-500.

Herrera L.P., Panigatti J.L., Barral M.P., Blanco D.E. 2013. Biofuels in Argentina. Impacts of Soybean Production on Wetlands and Water. Buenos Aires. *Fundación para la Conservación y el Uso Sustentable de los Humedales, Wetlands International Argentina.*

Hudson P.J., Dobson A.P., Lafferty K. 2006. Is a healthy ecosystem one that is rich in parasites? *Trends in Ecology & Evolution* 21(7): 381-385.

Johnson P.T.J., Chase J.M. 2004. Parasites in the food web: linking amphibian malformations and aquatic eutrophication. *Ecology Letters* 7: 521-526.

Johnson P.T.J., Sutherland D.R. 2003. Amphibian deformities and *Ribeiroia* infection: an emerging helminthiasis. *Trends in Parasitology* 19(8): 332-335.

Johnson P.T.J., Chase J.M., Dosch K.L., Gross J., Hartson R.B., Larson D., Sutherland D.R., Carpenter S.R. 2007. Aquatic eutrophication promotes pathogenic infection in amphibians. *Proceedings of the National Academy of Sciences* 104: 15781-15786.

Jones A. 2005. Superfamily Paramphistomoidea Fishoeder, 1901. *In:* Jones A., Bray R.A., Gibson D.I. (eds), Keys to the Trematoda. Vol. 2. *CABI Publishing and The Natural History Museum, Wallindford*, pp. 221-356.

Kehr A.I., Hamann M.I. 2003. Ecological Aspects of Parasitism in the Tadpole of *Pseudis paradoxa* from Argentina. *Herpetological Review* 34(4): 336-341.

Khalil L.F., Jones A., Bray R.A. 1994. Keys to the cestode parasites of vertebrates. *CAB International, Wallingford,* 768 pp.

Koprivnikar J., Forbes M.R., Baker L. 2006. Environmental factors influencing trematode prevalence in grey tree frog (*Hyla versicolor*) tadpoles in southern Ontario. *Journal of Parasitology* 92: 997-1001.

Koprivnikar J., Marcogliese D.J., Rohr J.R., Orlofske S.A., Raffel T.R., Johnson P.T.J. 2012. Macroparasite infections of amphibians: what can they tell us? *EcoHealth* 9: 342-360.

Krebs C.J. 1999. Ecological Methodology, 2nd ed. *Menlo Park, CA: Longman*, 620 pp.

Lafferty K.D., Kuris A.M. 1999. How environmental stress affects the impacts of parasites. *Limnology and Oceanography* 44 (3, part 2): 925-931.

Langone J.A. 1994. Ranas y sapos del Uruguay (reconocimiento y aspectos biológicos). *Museo Damasco Antonio Larrañaga. Serie Divulgación* 5: 1-120.

Maneyro R., Naya D., Rosa I., Canavero A., Camargo A. 2004. Diet of the South American frog *Leptodactylus ocellatus*

(Anura: Leptodactylidae) in Uruguay. *Iheringia, Série Zoologia* 94(1): 57-61.

Mañé-Garzón F. 1958. Un nouveau trématode des batraciens de l'Uruguay: *Catadiscus corderoi* n. sp. *Comunicaciones Zoológicas del Museo de Historia Natural de Montevideo* 78(4): 1-5.

Marcogliese D.J. 2005. Parasites of the superorganism: are they indicators of ecosystem health? *International Journal for Parasitology* 35: 705-716.

Marcogliese D.J., Cone D.K. 1997. Parasite communities as indicators of ecosystem stress. *Parasitologia* 39: 227-232.

Marcogliese D.J., Pietrock M. 2011. Combined effects of parasites and contaminants on animal health: parasites do matter. *Trends in Parasitology* 27: 123-130.

McAlpine D.F. 1997. Helminth communities in bullfrogs (*Rana catesbeiana*) green frogs (*Rana clamitans*) and leopard frogs (*Rana pipiens*) from New Brunswick, Canada. *Canadian Journal of Zoology* 75: 1883-1890.

McKenzie V.J. 2007. Human land use and patterns of parasitism in tropical amphibian host. *Biological Conservation* 137: 102-116.

Nakao M. 2016. *Pseudoacanthocephalus toshimai* sp. nov. (Palaeacanthocephala: Echinorhynchidae), a common acanthocephalan of anuran and urodelan amphibians in Hokkaido, Japan, with a finding of its intermediate host. *Parasitology International* 65(4): 323-332

Ostrowski de Núñez M. 1978/1979. Fauna de agua dulce de la república Argentina. IX. Sobre representantes de la familia Paramphistomatidae (Trematoda). *Physis* B38 (95): 55-62.

Petrochenko V.I. 1971a. Acanthocephala of domestic and wild animals. Vol. 1. *Keter Press, Jerusalem*, 465 pp.

Petrochenko V.I. 1971b. Acanthocephala of domestic and wild animals. Vol. 2. *Keter Press, Jerusalem*, 478 pp.

Pielou E.C. 1969. An Introduction to Mathematical Ecology. *Wiley-Interscience John Wiley and Sons, N,* 294 pp.

Poulin R. 1992. Toxic pollution and parasitism in freshwater fish. *Parasitology Today* 8: 58-61.

Poulin R. 1996. Sexual inequalities in helminth infections: a cost of being a male? *Annual Review of Ecology, Evolution, and Systematics* 147: 287-295.

Poulin R. 2007. Are there general laws in parasite ecology? *Parasitology* 134: 763-776.

Poulin R., Morand S. 2004. Parasite biodiversity. *Smithsonian Institution Books, Washington, DC,* 216 pp.

Price P.W. 1990. Host populations as resources defining parasite community organization. *In:* Esch G., Bush A., Aho J. (eds), Parasite communities: Patterns and processes. *Chapman and Hall, New York*, pp. 21-40.

Shannon C.E., Weaver W. 1949. The Mathematical Theory of Communication. *University Illinois Press. Urbana, Illinois,* 125 pp.

Stumpf I.V.K. 1981/1982. Ciclo evolutivo da *Cylindrotaenia americ*ana Jewell, 1916 (Cyclophyllidea: Nematotaeniidae) em *Bufo ictericus* Spix, 1824. *Acta biológica paranaense* 10/11: 31-39.

Sullivan J.J. 1977. Revision of the genus *Rauschiella* Babero, 1951 (Digenea: Plagiorchiidae) with a redescription of *R. palmipedis* (Lutz, 1928) n. comb. from venezuelan frogs. *Proceedings of the Helminthological Society of Washington* 44: 82-86.

Sures B. 2004. Environmental parasitology: relevancy of parasites in monitoring environmental pollution. *Trends in Parasitology* 20: 170-177.

Travassos L. 1925. Contribuições para o conhecimento da fauna helmintológica dos batráchios do Brasil. Nematódeos intestinais. *Sciencia Medica* 3(1): 673-687.

Travassos L. 1931. Pesquisas helmintológicas realizadas em Hamburgo. IX Ensaio monográfico da família Cosmocercidae Trav., 1925 (Nematoda). *Memórias do Instituto Oswaldo Cruz* 25(3): 237-298.

Thul J.E., Donald D.J., Abercrombies C.L. 1985. Ecology of Parasitic Helminths of Wood Ducks, *Aix sponsa*, in the Atlantic Flyway. *Proceedings of the Helminthological Society of Washington* 52(2): 297-310.

Toledo G.M., Morais D.H., Silva R.J., Anjos L.A. 2015. Helminth communities of *Leptodactylus latrans* (Anura: Leptodactylidae) from the Atlantic rainforest, south-eastern Brazil. *Journal of Helminthology* 89 250-254.

Vicente J.J., Santos E. 1976. Fauna helmintológica de *Leptodactylus ocellatus* (L., 1758) de Volta Redonda, Estado do Rio de Janeiro. *Atas da Sociedade de Biologia do Rio de Janeiro* 18(1): 27-42.

Yamaguti S. 1961. Systema Heminthum. Vol. 3. The nematodes of vertebrate. *Interscience Publishers Inc, New York*, 1261 pp.

Yamaguti S. 1963. Systema Helminthum. Vol. 5. Acanthocephala. *Interscience Publishers Inc, New York*, 423 pp.

Zank C., Di-Bernardo M., Maneyro R., Colombo P., Fusinatto L.A., da Fonte L.F.M. 2010. Spatial and temporal distribution of *Pseudis minuta* (Anura, Hylidae, Hylinae) and environmental variables related to its reproductive activity in Reserva Biológica do Lami, southern Brazil. *Iheringia, Série Zoologia* 100(2): 145-150.

Zuur A.F., Leno E.N., Walker N.J., Saveliev A.A., Smith G.M. 2009. Mixed Effects Models and Extensions in Ecology with R. *Springer, New York,* 574 pp.

Revue suisse de Zoologie (September 2020) 127(2): 275-313 ISSN 0035-418

Karakumosa gen. nov., a new Central Asian genus of fossorial wolf spiders (Araneae: Lycosidae: Lycosinae)

Dmitri V. Logunov[1]* & Alexander V. Ponomarev[2]

[1] *The Manchester Museum, The University of Manchester, Oxford Road, Manchester M13 9PL, UK.*
[2] *Southern Scientific Centre of the Russian Academy of Sciences, Chekhov street 41, Rostov-on-Don, 344006, Russia. E-mail: ponomarev1952@mail.ru*
* *Corresponding author: dmitri.v.logunov@manchester.ac.uk*

Abstract: A new genus, *Karakumosa* gen. nov., is established to accommodate nine central Asian species of burrowing wolf spiders, of which seven are diagnosed and described as new: *K. badkhyzica* sp. nov. (♂♀, southern Turkmenistan), *K. gromovi* sp. nov. (♂♀, southern Uzbekistan), *K. repetek* sp. nov. (♂♀, eastern Turkmenistan), *K. shmatkoi* sp. nov. (♂♀, northern Ciscaspian region and Azerbaijan), *K. tashkumyr* sp. nov. (♂, Kyrgyzstan), *K. turanica* sp. nov. (♂♀, Turkmenistan), *K. zyuzini* sp. nov. (♂♀, Uzbekistan). Two generic transfers are proposed: *Karakumosa alticeps* (Kroneberg, 1875), comb. nov. and *K. medica* (Pocock, 1889), comb. nov. (both ex *Hogna* Simon, 1885). Lectotypes are designated for *Tarentula alticeps* Kroneberg, 1875 (♂) and *T. medica* Pocock, 1889 (♂). The localities of all *Karakumosa* species are mapped, and an identification key is provided as well. A short overview of the fauna and diversity of the fossorial Lycosidae of Central Asia is given.

Keywords: Taxonomy - descriptions - identification key.

INTRODUCTION

Fossorial wolf spiders of the family Lycosidae Sundevall, 1833 of Central Asia have been studied inadequately and remain poorly understood taxonomically (for an overview see Logunov, 2010). Central Asia is here defined as the territory of traditional Middle Asia and Kazakhstan plus the northern Ciscaspian region (Dagestan, Kalmykia, etc.), eastern Azerbaijan, and the neighbouring territories of western China, including Tibet, northern Pakistan, Afghanistan and Iran. To date, 30 species of burrowing lycosids have been recorded/described from Central Asia (Table 1) (Mikhailov, 2013; Otto, 2020; Roewer, 1955a; Song *et al.*, 1999; Zamani *et al.*, 2020; present data). However, many of the earlier records were based on doubtful identifications which are difficult to interpret and/or impossible to verify because the corresponding material is not accessible or its whereabouts is unknown. For instance, the species *Hogna alticeps* (Kroneberg, 1875), as it is listed now in the World Spider Catalog (2020), has been recorded from Central Asia many times (Andreeva, 1975, 1976; Kroneberg, 1875; Mikhailov & Fet, 1994; Ovtsharenko & Fet, 1980; Schmidt, 1895; Simon, 1899; Vlassov & Sytshevskaja, 1937; Zyuzin *et al.*, 1994), but the distribution and even the taxonomy of this species remain largely unresolved. As it is evident from our study, the species is clearly neither a member of *Hogna* Simon, 1885, nor of *Lycosa* Latreille, 1804, and only few of the earlier records of *H. alticeps* actually correspond to this species. The same holds true for *Hogna medica* (Pocock, 1889), which was described from north-western Afghanistan (Pocock, 1889: sub *Tarentula medica*) and then reported once from Uzbekistan (Schmidt, 1895: sub *Lycosa medica*). Since then nobody has recorded this species from Central Asia again. The present paper attempts to bring some clarity to the taxonomy and distribution of these species, and to rectify their generic placement. The paraphyletic genera *Hogna* and *Lycosa* still remain two of those lycosid genera that are "used as a 'dumping ground' for wolf spiders that could not be satisfactory placed in other genera" (Murphy *et al.*, 2006: 585).

The aim of the present work is to propose a new genus of fossorial wolf spiders from Central Asia to accommodate nine distinct species. Two of these are here transferred from *Hogna*, and seven species are diagnosed and described as new. The localities of all species are mapped and an identification key to all of them is provided. Finally a short overview of the fauna of fossorial Lycosidae of Central Asia is given.

Manuscript accepted 09.06.2020
DOI: 10.35929/RSZ.0021

MATERIAL AND METHODS

A total of 114 specimens have been examined for the present paper. They were borrowed from or deposited in the following museums: BMNH = The Natural History Museum, London, UK (curator: J. Beccaloni); MHNG = Muséum d'histoire naturelle, Genève, Switzerland (curator: P.J. Schwendinger); MMUE = Manchester Museum, University of Manchester, Manchester, UK (curator: D.V. Logunov); ISEA = Institute of Systematics and Ecology of Animals, Novosibirsk, Russia (curator: G.N. Azarkina); PSU = Department of Invertebrate Zoology and Aquatic Ecology of the Perm State University, Perm, Russia (curator: S.L. Esyunin); ZISP = Zoological Institute of the Russian Academy of Sciences, St-Petersburg, Russia (curator: V.A. Krivokhatsky); ZMMU = Zoological Museum of the Moscow University, Moscow, Russia (curator: K.G. Mikhailov).

All SEM micrographs, except for Figs 9-11, were taken with the assistance of A.V. Nazarenko (Rostov-on-Don, Russia) by means of a Carl Zeiss EVO 40 XVP scanning electron microscope at the Center for Collective Usage 'Joint Centre of scientific and technological equipment of the Southern Scientific Centre of the Russian Academy of Sciences (research, development, approbation)', Rostov-on-Don, Russia. The SEM micrographs of *K. alticeps* (Figs 9-11) were taken by Yu.M. Marusik (Magadan, Russia) with a Jeol JSM-5200 stereo scanning electron microscope at the Zoological Museum, University of Turku, Finland; he also compiled some digital photos (Figs 17-21). The majority of digital photos (Figs 32-39, 44, 49-54, 59, 61, 70-72, 89-93, 103-106, 117, 122, 126, 127, 130, 136, 137, 140, 161-165, 171) were taken by V.Yu. Shmatko (Rostov-on-Don, Russia) using a Sony Alpha A6000 ILCE-6000 Camera attached either to a Mikmed-2 var. 2 microscope (for general appearances) or to a MBS-1 microscope with a VOLNA-9 Lens (for copulatory organs). Digital photos of the male bulbs of *K. alticeps* (Figs 12-16) were taken by A.A. Fomichev (Novosibirsk, Russia) with an Olympus DP74 camera attached to an Olympus SZX 16 stereomicroscope at the Altai State University, Barnaul, Russia. Some digital photographs (Figs 27, 77-80, 85, 159) were made by the first author at the World Museum of Liverpool (UK) using a Canon 6D Mark II Camera with a Canon MP-E 65mm lens with Helicon Remote ver. 3.9.7W to control the StackShot 3X Macro Rail and camera settings. Helicon Focus 6.8.0 was used as processing software. Distribution maps were produced by G.N. Azarkina (Novosibirsk, Russia) using the online mapping software SimpleMappr (Shorthouse, 2010).

The terminology of sclerites of the copulatory organs follows Zyuzin (1993), except for the term 'median apophysis' which is used *sensu* Griswold (1993) and Logunov (2010). The term 'palea' refers to a swollen, partially membranous part of the embolic division from which the synembolus and the embolus originate (Figs 9-13: Pl). Short spines occurring on the ventral surface of tarsi in some lycosine genera (e.g. *Lycosa*, *Zyuzicosa* Logunov, 2010; Figs 140-141) were referred to by Zyuzin (1990) as 'spinules', a term which is also adopted here. 'Chelicera length' refers to the frontal length of the basal cheliceral segment on intact specimens; chelicerae were not removed from the specimens. The clypeus is the area between the AMEs and the frontal margin of the carapace. The sequence of leg segment measurements is as follows: femur + patella + tibia + metatarsus + tarsus (total). The leg formula is given from longest to shortest leg. All measurements are in mm.

Abbreviations

AER	anterior row of eyes
AME	anterior median eye
ALE	anterior lateral eye
a.s.l.	above sea level
C	conductor
D	described
Distr.	district
E	embolus
IP	inner plate of the MA
MA	median apophysis
Mt	metatarsus
MT	median tooth of the MA
OP	outer plate of the MA
PE	proximal extension of the MA
Pl	palea
PLE	posterior lateral eye
PME	posterior median eye
Se	synembolus
SER	of second row of eyes (formed by PMEs)
St	subtegulum
T	tegulum
Tb	tibia
TL	type locality
Tr	tarsus
Vil.	village

TAXONOMIC PART

Family Lycosidae Sundevall, 1833
Subfamily Lycosinae Sundevall, 1833

Genus *Karakumosa* gen. nov.

Type species: *Karakumosa repetek* sp. nov. from the Repetek Reserve, Karakumy Desert, Turkmenistan, Central Asia (male holotype deposited in the ISEA).

Diagnosis: The genus *Karakumosa* gen. nov. belongs to the subfamily Lycosinae (*sensu* Zyuzin, 1993; see Dondale, 1986; Murphy *et al.*, 2006; Piacentini & Ramírez, 2019) and is most similar to *Zyuzicosa* Logunov, 2010 (see Logunov, 2010, 2012). Both genera have a bipartite/biramous synembolus, the same SER/AER ratio (more than 1.3), tarsi of all legs

with scopulae and spinules, and a prolatero-apical origin of the embolus. The new genus differs from all other Central Asian Lycosinae genera (see Logunov, 2010: table 2), including *Zyuzicosa*, by the following combination of characters: black ventral colour pattern of abdomen absent (Figs 25, 52, 91, etc.); median apophysis consisting of two flat plates (Figs 55, 118: OP, IP); synembolus with two acutely pointed lamellae (Figs 57, 98-99, 116, 118, 129, 149, 163, 175); epigynal atrium at least twice longer than wide; and septal pedicel absent (Figs 27, 44, 61, 72, 85, 96).

Etymology: The new generic name is composed of two parts: 'Karakum', referring to the regional name for the Karakumy Desert where the type species and some other species were discovered, combined with the ending of the generic name *Lycosa* (meaning 'tear like a wolf'; see Cameron, 2005: 303), to which the majority of large burrowing Holarctic wolf spiders are currently assigned. The generic name is feminine in gender.

Description: Large to very large fossorial wolf spiders, with body lengths 20.23±3.23 (n=8) in males, and 22.9±4.05 (n=7) in females.

Carapace: In both sexes relatively low, with a clearly marked gradual descent from cephalic region towards abdomen (Figs 26, 35, 54, 78, 138, 158), densely clothed with white or yellowish white setae, and with prominent dense white or yellowish marginal pubescence; all three characters are typical of lycosid burrowers (see Zyuzin, 1990).

Chelicerae: Large, vertical, their proximal halves/two-thirds of frontal side densely clothed with white or yellowish setae (Figs 32, 53, 79, 136); cheliceral groove with three promarginal and three retromarginal teeth (Figs 144, 177).

Eyes: AER procurved and distinctly (1.3-1.4 times) shorter than SER (Figs 32, 53, 136); PME/AME ratio 1.7-2.5.

Clypeus: Narrow, its height equal or 1.3-1.7 times shorter than AME diameter.

Labium: Visibly wider than long (length/width ratio 0.6-0.8).

Sternum: Ovoid, densely covered with white setae in both sexes (e.g. Figs 23, 49, 52, 137).

Abdomen: Venter in both sexes without black pattern (e.g. Figs 25, 52, 91), thus distinct from the majority of Palaearctic burrowing lycosine genera described to date (see Simon, 1876; Logunov, 2010, 2012).

Legs: leg formula IV,I,II,III in both sexes, rarely IV,II,I,III in some males; all segments densely covered with white setae; in both sexes, metatarsi and tarsi I-II ventrally with well-developed scopulae and longitudinal rows of spinules (sometimes poorly visible; Figs 36, 63, 140), tarsi III-IV only with ventral longitudinal rows of spinules (in some specimens a scopula could be developed on lateral sides of segments only; Fig. 141).

Female pedipalp: With a single tarsal claw (e.g. Figs 26, 35, 138).

Female copulatory organs: Epigyne with a well pronounced longitudinal atrium being at least two times longer than wide; edges at proximal end of atrium forming two round convergent lips, these usually markedly sclerotized and darker (brown or russet) than nearby cuticle (e.g. Figs 27, 61, 85); septal pedicel absent; median septum essentially reduced to posterior transverse, slightly convex plate of variable shape (e.g. Figs 27, 96); spermathecae tube-shaped, only slightly wider than or of same width as narrow and short insemination ducts (e.g. Figs 28, 43, 62, 121).

Male pedipalp: Femur length equal to that of patella+tibia (Figs 15-16); cymbium symmetrical, twice as long as wide, with almost round alveolus (Fig. 65), its length about equal to that of palpal tibia; distal part of cymbium 1.1-1.3 times shorter than alveolus length (Fig. 65); cymbium with a cluster of blunt, rigid and straight bristles on its tips (Figs 45, 69) as typical of lycosid burrowers (Zyuzin, 1990, 1993).

Male copulatory organs: Subtegulum round and comparatively small, situated in proximal-mesal position (Figs 9, 46, 56, 98: St); tegulum round and broad, in unexpanded palp clearly visible only on prolateral-proximal side of bulbus (Figs 55, 98, 118: T); median apophysis wide (usually wider than long) and broad (Figs 9, 55, 118: OP, IP), folded along its proximal edge and consisting of two (outer and inner) flat plates, the outer plate bearing a proximal extension and a median tooth (Figs 56, 98: MT, PE); median tooth rarely singular and finger-shaped (Figs 30, 42), usually consisting of a lateral claw and a median edge bearing micro-teeth (indicated by arrow in Figs 123, 128) and in some species with a low serrate flange at its foot (indicated by arrow in Figs 125, 134, 152); synembolus biramous, with two acutely pointed lamellae (Figs 57, 98, 118: Se); a triangular hyaline conductor present, well-developed and pointed ventrad (Figs 12, 56, 118: C); embolus thin, with a rather wide and prominent pars pendula (Figs 4, 116, 129), its origin in a prolatero-apical position, with only the embolic tip visible in between or beneath branches of the synembolus in unexpanded palp (Fig. 57).

Comments: Within the Lycosoidea the transverse median apophysis is considered a typical feature of the Lycosidae (Griswold, 1993) and a synapomorphy of the Lycosinae (Dondale, 1986), although its shape varies. In *Karakumosa* gen. nov. the median apophysis is large and composite, consisting of two distinct plates that appear fused along their proximal edges: the outer and the inner plates (e.g. Figs 9, 56, 118: OP, IP). Such a complex structure of the median apophysis is currently regarded as unique within the Lycosinae and within the entire family Lycosidae. Of the lycosid genera known to us, only two have a comparably complex structure of the median apophysis: *Oculicosa* Zyuzin, 1993 (Logunov & Gromov, 2011: figs 1-2) and *Zyuzicosa* (Logunov, 2010: figs 34-39). The outer plate of the

median apophysis of *Karakumosa* gen. nov., with its proximal extension and median tooth of MA, looks like an apomorphic modification of the prominent transverse chitinous ridge of the median apophysis in *Oculicosa*. Obviously, both structures are homologous.

Another unique feature of *Karakumosa* gen. nov. is its biramous synembolus, consisting of two thin and very acutely pointed lamellae (e.g. Figs 4, 57, 67, 116). The only other lycosid genus with a comparable conformation of the synembolus is *Zyuzicosa* (Logunov, 2010: figs 64, 66), but in the latter genus it consists of one acutely pointed lamella and a wide, strongly sclerotized base.

In the absence of a phylogenetic analysis of the Palaearctic genera of Lycosidae (but see Murphy *et al.*, 2006; Piacentini & Ramírez, 2019), it is difficult to establish whether both unique features of *Karakumosa* gen. nov. are primitive or derived (they are likely to be derived). Yet, as a provisional hypothesis to be further tested, we consider both of them as the putative synapomorphies of *Karakumosa* gen. nov.

We speculate that if the genus *Karakumosa* gen. nov. was included in one of the two latest phylogenetic analyses of the Lycosidae based on DNA data (Murphy *et al.*, 2006; Piacentini & Ramírez, 2019), it would likely be placed either within the clade E (*sensu* Murphy *et al.*, 2006: figs 2-3), somewhere close to *Lycosa tarantula* (Linnaeus, 1758) and the clade E1, or within the Lycosinae (*sensu* Piacentini & Ramírez, 2019: fig. 4), in the branch containing the Palaearctic *Lycosa* species.

Composition: To date nine species are assigned to *Karakumosa* gen. nov.: *K. alticeps* (Kroneberg, 1875), comb. nov. (♂♀, Uzbekistan and southern Kazakhstan), *K. badkhyzica* sp. nov. (♂♀, Turkmenistan), *K. gromovi* sp. nov. (♂♀, southern Uzbekistan), *K. medica* (Pocock, 1889), comb. nov. (♂♀, north-western Afghanistan), *K. repetek* sp. nov. (♂♀, Turkmenistan), *K. shmatkoi* sp. nov. (♂♀, northern Ciscaspian region and Azerbaijan), *K. tashkumyr* sp. nov. (♂, Kyrgyzstan), *K. turanica* sp. nov. (♂♀, Turkmenistan), *K. zyuzini* sp. nov. (♂♀, Uzbekistan).

Distribution: Central Asia (Fig. 1): (semi)desert regions of the northern Ciscaspian Region, eastern Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, Turkmenistan and north-western Afghanistan; the occurrence of this genus in northern and north-eastern Iran and Tajikistan is very likely.

The genus is essentially restricted to the so-called Turan zoogeographic province (*sensu* Kryzhanovsky, 2002) (Fig. 1). It is the third genus of fossorial wolf spiders within the currently known Lycosinae that is confined to Central Asia (Table 1). The other two are *Oculicosa* (see Zyuzin, 1993; Logunov & Gromov, 2011: fig. 6) and *Zyuzicosa* (see Logunov 2010, 2012: map), but their ranges are markedly smaller and of a different configuration. *Karakumosa* gen. nov. seems to be a typical Turan genus (*sensu* Pravdin & Mishchenko, 1980) and an endemic to Central Asia; its geographical range lies within the Turan lowlands of the desert zone. We are unaware of any other Central Asian spider genus that has a distributional pattern similar to that of *Karakumosa* gen. nov.

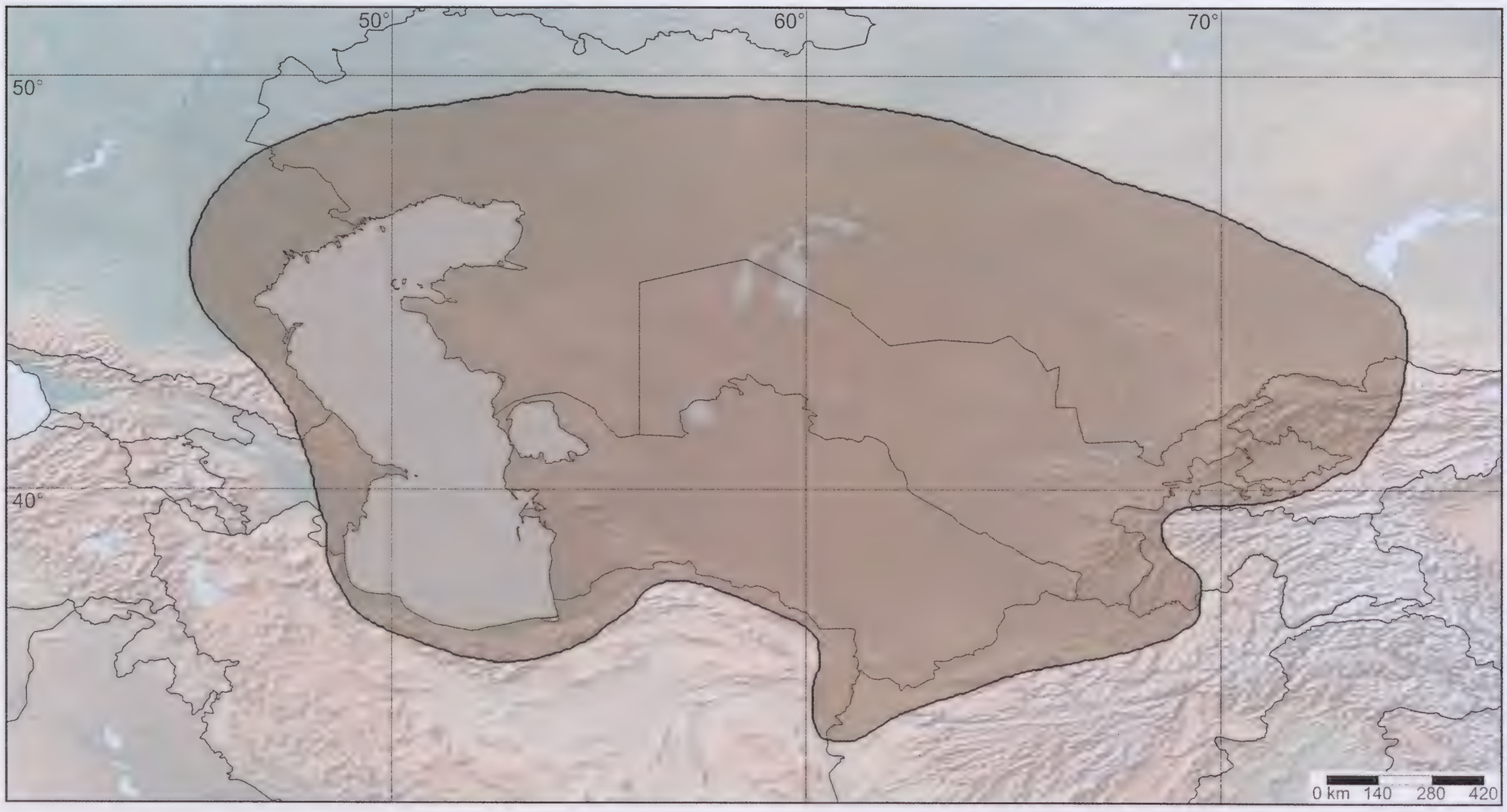


Fig. 1. Geographical range of the genus *Karakumosa* gen. nov.

Key to the species of *Karakumosa* gen. nov.

The female of *K. tashkumyr* sp. nov. remains unknown and thus is not included here.

1A Males 2
1B Females 10

2A Proximal extension of median apophysis clearly hook-shaped (Figs 60, 118, 150) 3
2B Proximal extension of median apophysis of a different shape (Figs 2, 46, 83, 98) 5

3A Median tooth of median apophysis with a low serrate flange at its foot (indicated by arrow in Figs 125, 134, 152) 4
3B Median tooth of median apophysis without such flange (Figs 66, 74-75) ..... *gromovi* sp. nov.

4A Inner plate of median apophysis as wide as outer plate, clearly visible in ventral view (indicated by arrow in Fig. 148); tips of both synembolic lamellae markedly bent downward (Fig. 149) ..... *tashkumyr* sp. nov.
4B Inner plate of median apophysis comparatively narrower and almost hidden beneath outer plate (indicated by arrow in Fig. 118); synembolic lamellae straight or with tips only slightly bent downward (Fig. 116) ..... *shmatkoi* sp. nov.

5A Proximal extension of median apophysis prominent (Figs 46, 83, 98) 6
5B Proximal extension of median apophysis not prominent (Fig. 174) ..... *zyuzini* sp. nov.

6A Proximal extension of median apophysis spade/spatula-like, as wide as long (Figs 46, 98) 7
6B Proximal extension of median apophysis wider than long (Figs 2, 83, 161) 8

7A Median tooth of median apophysis finger-shaped (Figs 31, 42) ..... *badkhyzica* sp. nov.
7B Median tooth of median apophysis bifurcated at its tip (Fig. 100) ..... *repetek* sp. nov.

8A Median tooth of median apophysis flat, without a ventral bulge (Figs 5, 164) 9
8B Median tooth of median apophysis with a ventral bulge (Fig. 87) ..... *medica*

9A Proximal extension of median apophysis twice as wide as long, with a markedly pointed prolaterad-directed shoulder (Fig. 161); median tooth quadrangular (Fig. 164) ..... *turanica* sp. nov.
9B Proximal extension of median apophysis triangular, with an obtuse prolaterad-directed shoulder (Fig. 12); median tooth triangular, with a serrate prolateral edge (Figs 5-8) ..... *alticeps*

10A Edges of epigynal atrium subparallel or slightly bent outward (Figs 44, 61, 72, 85) 11
10B Edges of epigynal atrium slanted to each other; atrium anteriorly clearly narrower than posteriorly (Figs 27, 96) 13

11A Edges of epigynal atrium subparallel (Figs 61, 85), spermathecae as in Figs 62, 86 12
11B Edges of epigynal atrium slightly bent outward (biconvex), atrium barrel-shaped (Fig. 44), spermathecae as in Fig. 43 ..... *badkhyzica* sp. nov.

12A Posterior transverse plate of epigyne in the shape of an inverted triangle (Figs 61, 72), spermathecae markedly widened anteriorly (Figs 62, 73) ..... *gromovi* sp. nov.
12B Posterior transverse plate of epigyne anchor-shaped (Fig. 85), spermathecae not widened anteriorly, worm-shaped (Fig. 86) ..... *medica*

13A Posterior transverse plate more or less anchor-shaped (Figs 27, 167-168), spermathecae curved anticlockwise or subparallel (Figs 28, 121, 166) 14
13B Posterior transverse plate dumbbell-shaped (Fig. 96), spermathecae curved clockwise (Fig. 95) ... *repetek* sp. nov.

14A Epigynal atrium markedly narrowed at its anterior end, pawn-shaped (Figs 27, 122) 15
14B Epigynal atrium much less narrower at its anterior end, with almost subparallel lateral edges (Figs 167, 179) .. 16

15A Posterior transverse plate of epigyne in the shape of a low inverted triangle, epigynal edges strongly sigmoid (Fig. 122); spermathecae markedly swollen in anterior portion (Fig. 121) ..... *shmatkoi* sp. nov.
15B Posterior transverse plate of epigyne slightly procurved, epigynal edges indistinctly sigmoid (Fig. 27); spermathecae not swollen anteriorly (Figs 28-29) ..... *alticeps*

16A Posterior transverse plate of epigyne with straight posterior margin (Fig. 179); spermathecae distinctly inclined towards each other (Fig. 182) ..... *zyuzini* sp. nov.
16B Posterior transverse plate of epigyne anchor-shaped, with convex posterior margin (Fig. 167); spermathecae more or less parallel to each other (Fig. 166) ..... *turanica* sp. nov.

Karakumosa alticeps (Kroneberg, 1875) comb. nov.

Figs 2-29, 76

Tarentula alticeps Kroneberg, 1875: 40, pl. 4, fig. 28 (description of male and female; syntypes in the ZMMU).
Lycosa alticeps. – Schmidt, 1895: 449 (partim). – Zyuzin *et al.*, 1994: 4, 9.
Hogna alticeps. – Roewer, 1955b: 247.

Lectotype (designated here; Figs 17-21): ZMMU, Ta-1219; male; "Turkestan region" (no exact locality); no date; [A.P.] Fedchenko (Turkestan scientific expedition of the Imperial Society of Devotees of Natural Science).

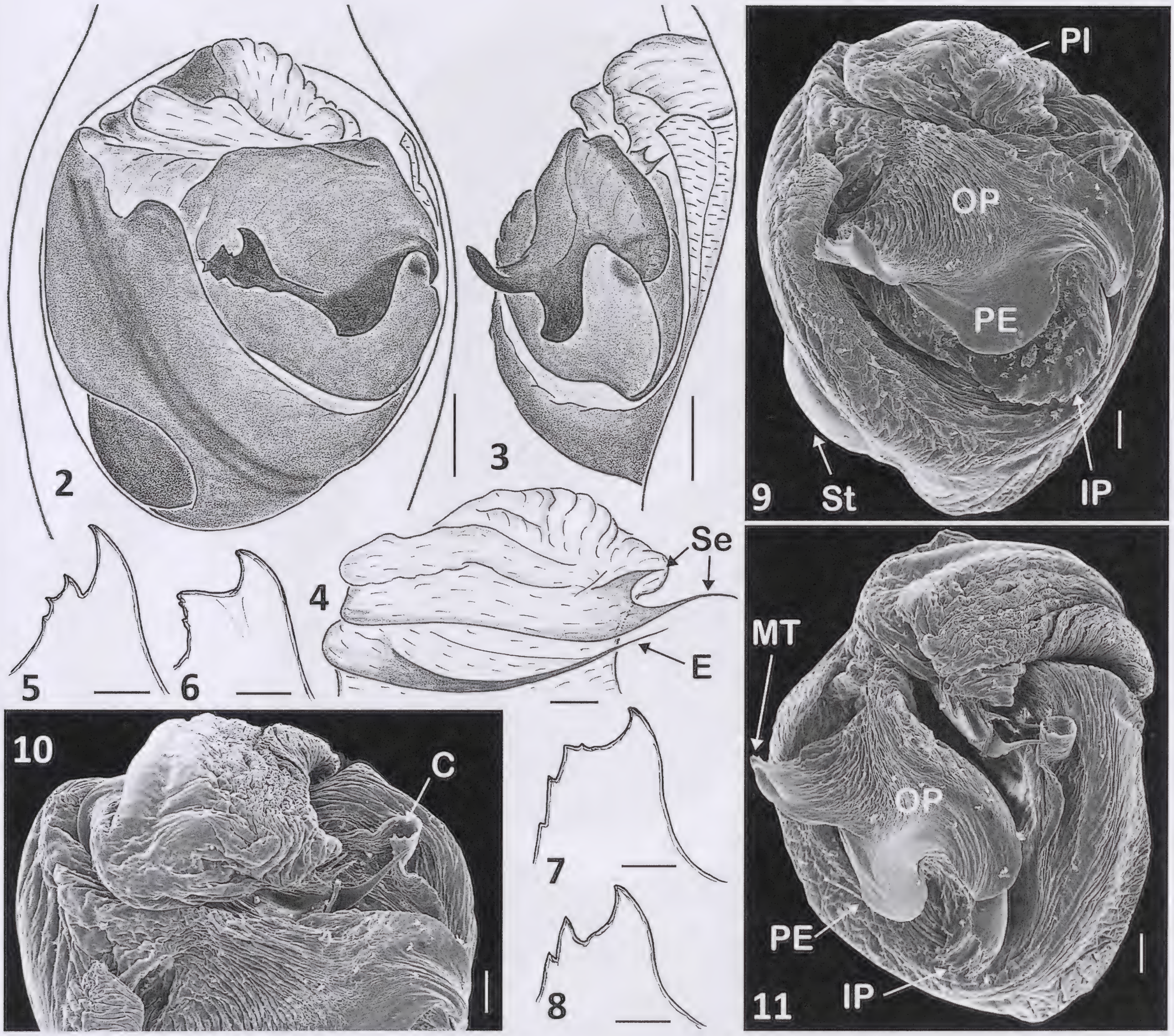
Paralectotype: ZMMU, Ta-1218; 1 male; [KAZAKHSTAN], "Dyusebai" [well] (an unknown locality, apparently in Chardara Distr. of South Kazakhstan Area); no date; [A.P.] Fedchenko (Turkestan scientific expedition of the Imperial Society of Devotees of Natural Science). For information about other former syntypes of *T. alticeps*, see below under *K. turanica* sp. nov.

Other material: ISEA, 001.8403; 6 males, 1 female; KAZAKHSTAN, Zhambyl Area, Chu Distr., c. 9th km of road from Tole Bi (= Novotroitskoe) to Moyyunkum, Chu river valley (c. 43°45'N, 73°46'E), sands; 31.V.-2.VI.1990; leg. A.A. Fedorov & A.A. Zyuzin. – MHNG; 2 males; same data. – ISEA 001.8404; 1 male, 1 female; KAZAKHSTAN, South Kazakhstan Area, Chardara Distr., Kyzyl-Kum Desert, Karatau Mt. Range, Karamola Mt. (c. 42°20'N, 67°45'E); [late May] 1994; leg. A.A. Zyuzin. – ZMMU; 1 male, 1 female; same data. – MMUE; 1 male, 1 female; same data. – MMUE; 1 male; KAZAKHSTAN, Turkestan Area, Syr Darya River valley, near Zhankel' Vil. (42°32'46.1"N, 68°10'42.7"E), tugay (=gallery forest), 191 m a.s.l.; 28.V.2017; leg. Yu.V. Dyachkov. – MMUE; 1 male; KAZAKHSTAN, Kyzylorda Area, Syr-Darya River valley, near Tartogay Vil. (44°24'42.8"N, 66°16'40.1"E), tugay (= gallery forest), 142 m a.s.l.; 12.VI.2017; leg. Yu.V. Dyachkov. – MMUE; 1 male, 3 females; KAZAKHSTAN, Almaty Area, Ili Distr., near Kapchagay (on left side of road before reaching town (c. 43°50'17.3"N 76°58'14.9"E), sands; 25.-26.V.1990; leg. A.A. Zyuzin.

Etymology: According to Parker (1980) the specific epithet could be translated as 'high headed', originating from the Latin '*altus*' meaning high, and '*caput*' meaning the head.

Diagnosis: The male of *K. alticeps* is most similar to that of *K. turanica* sp. nov., but can be easily distinguished by the narrower, obtuse prolaterad-directed shoulder of the proximal extension of the median apophysis of the palpal organ (wider and markedly pointed in *K. turanica* sp. nov.; Figs 2, 12 cf. Fig. 161) and by the comparatively smaller, triangular median tooth with a serrate median edge (wide and quadrangular in *K. turanica* sp. nov.; Figs 5-8 cf. Fig. 164). The female of *K. alticeps* is most similar to that of *K. shmatkoi* sp. nov., from which it can be distinguished by almost straight lateral edges of the epigynal atrium and by the narrow, slightly procurved posterior transverse plate (sigmoid edges and a low inverted triangle-shaped posterior transverse plate in *K. shmatkoi* sp. nov.; Fig. 27 cf. Figs 122, 139), as well as by the narrow, not swollen spermathecae (markedly swollen in *K. shmatkoi* sp. nov.; Fig. 28 cf. Fig. 121).

Description: Male (from Chu river valley; ISEA, 001.8403). *Measurements*: Carapace 10.00 long, 7.50 wide. Eye sizes and interdistances: AME 0.43, ALE 0.35, PME 1.10, PLE 1.05, AME-AME 0.25, AME-ALE 0.15, PME-PME 0.90 PME-PLE 1.90. Width of anterior eye row 2.10, of second row 2.80, of third row 3.40. Clypeus height 0.25; chelicera length 4.75. Abdomen 9.80 long, 6.50 wide. Length of leg segments: I 10.00 + 4.20 + 8.30 + 8.80 + 4.20 (35.50); II 8.50 + 4.20 + 7.60 + 8.70 + 4.50 (33.50); III 8.70 + 3.40 + 6.50 + 9.00 + 4.40 (32.00); IV 10.70 + 3.80 + 8.20 + 11.30 + 4.90 (38.90). Leg formula: IV, I, II, III.
Colouration in alcohol (Figs 22-23): Carapace brownish, with a wide median longitudinal yellowish white band of setae along the entire length of the carapace and two wide lateral brownish longitudinal bands of setae; carapace sides with wide marginal bands of white setae. Sternum light brown, densely covered with yellowish white setae. Maxillae brown. Labium brown, with a yellow tip. Chelicerae brown, proximal half of frontal side densely covered with yellowish white setae. Abdomen: dorsum densely covered with white setae, with a long, wide, yellow brownish cardiac mark outlined by a brown line;



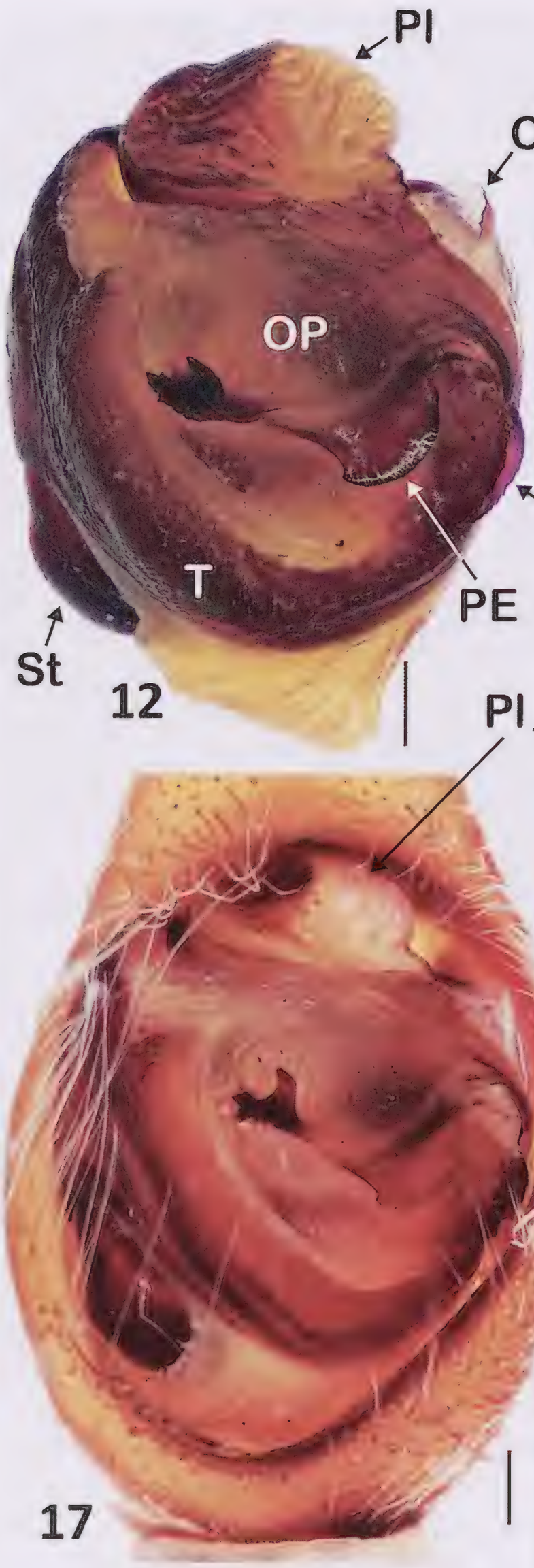
Figs 2-11. *Karakumosa alticeps* (Kroneberg, 1875), left male palp; specimens from Chu river valley (2-4, 7-11) and Karamola Mt. (5-6). (2, 9) Bulbus, ventral view. (3, 11) Ditto, retrolateral view. (4) Embolic division, ventral view. (5-8) Median tooth of MA, proximal view. (10) Bulbus, apical view. Scale bars 0.25 mm (2-3), 0.1 mm (4-11). Abbreviations as explained in Material and methods.

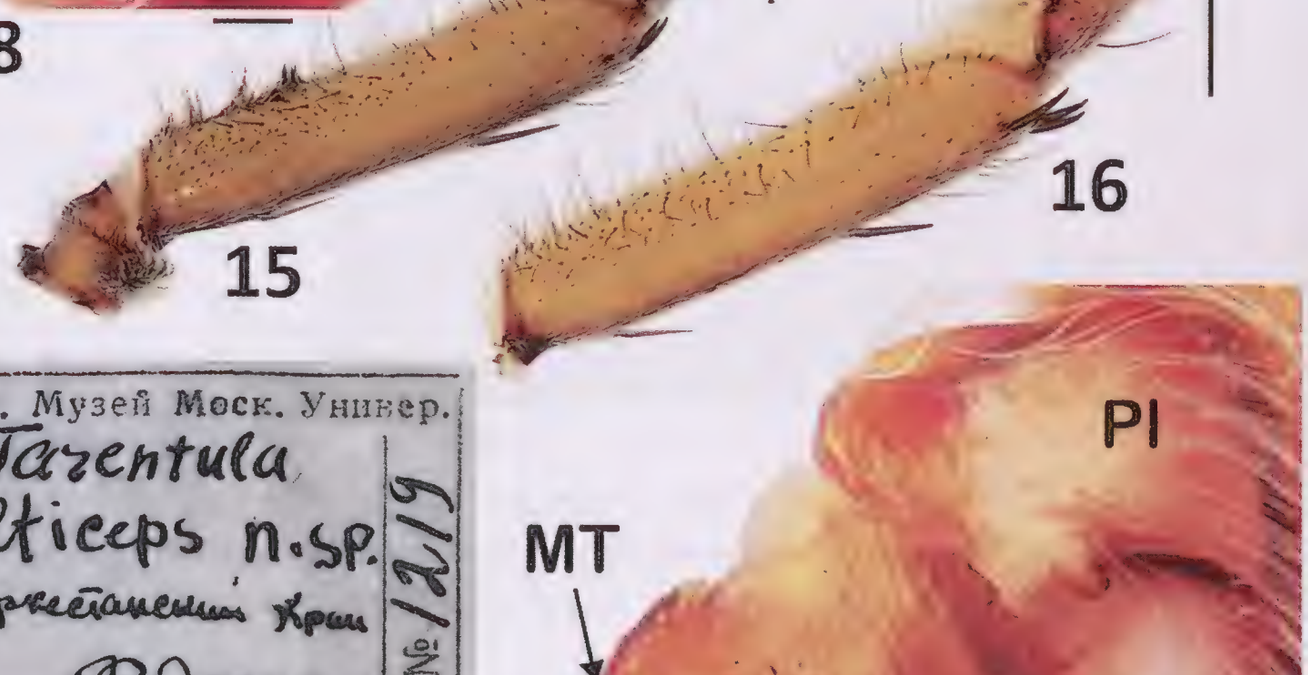
sides and venter densely covered with yellowish white setae. Book-lung covers yellow, covered with yellowish white setae. Spinnerets light brown. All legs yellow brownish, densely covered with white setae; Mt I and Tr I ventrally brown, but dorsally densely covered with white setae. Palp yellow, with brownish cymbium, densely covered with white setae.

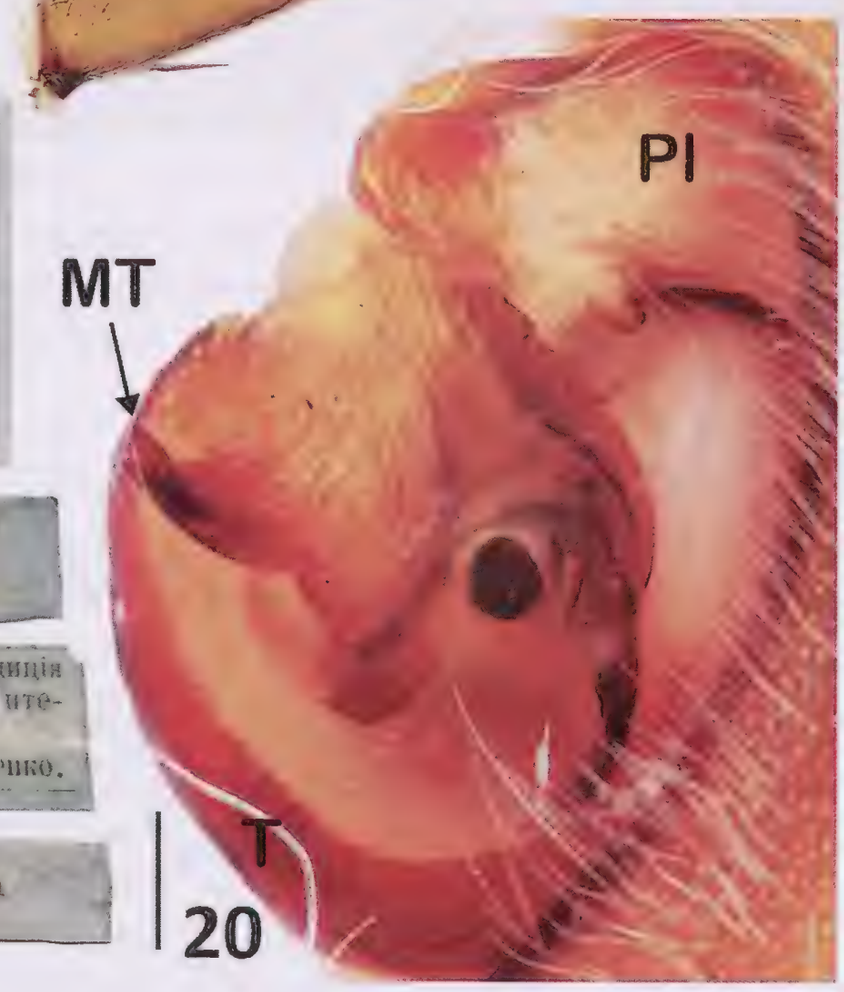
Palp structure (Figs 2-20): Acutely pointed synembolic lamellae subparallel to each other; median tooth medium-sized, notched at its tip and with a serrate median edge; proximal extension wide and obtuse at its prolaterad-directed shoulder; inner plate large and ovoid, clearly visible in ventral view; conductor triangular, acutely pointed and bent at its tip.

Female (from Chu river valley; ISEA, 001.8403). *Measurements*: Carapace 10.70 long, 8.00 wide. Eye sizes and interdistances: AME 0.50, ALE 0.45, PME 1.20, PLE 1.15, AME-AME 0.35, AME-ALE 0.15, PME-PME 1.15, PME-PLE 2.55. Width of anterior eye row 2.35, of second row 3.15, of third row 3.80. Clypeus height 0.20; chelicera length 5.75. Abdomen 12.00 long, 9.80 wide. Length of leg segments: I 9.30 + 4.10 + 7.20 + 6.50 + 3.80 (30.90); II 8.70 + 4.10 + 6.40 + 6.10 + 3.80 (29.10); III 7.70 + 3.50 + 5.60 + 6.70 + 4.00 (27.50); IV 10.00 + 4.00 + 7.20 + 9.20 + 4.70 (35.10). Leg formula: IV, I, II, III.

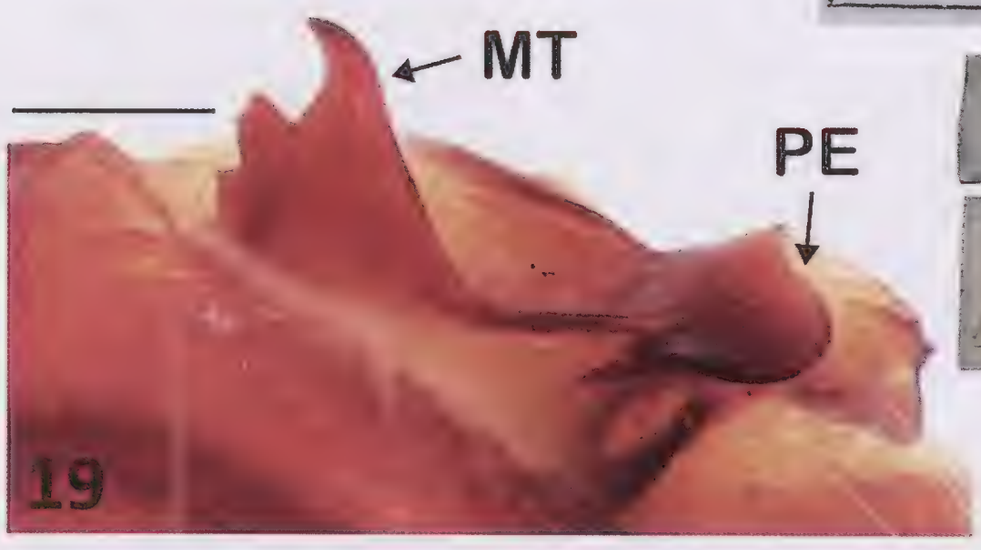
Colouration in alcohol (Figs 24-26): Carapace brownish, densely covered with yellowish white setae and with two longitudinal bands of brownish setae; carapace sides with

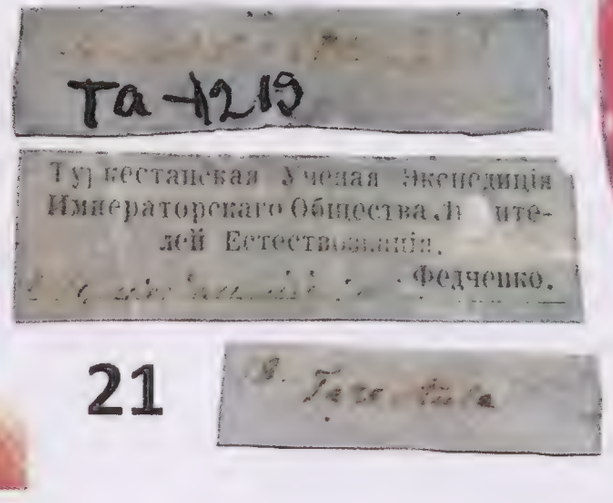






Зоолог. Музей Моск. Универ.
Ta | Tarentula alticeps n.sp. Туркестанскій Край Федченко | №1219





Figs 12-21. *Karakumosa alticeps* (Kroneberg, 1875); male specimens from Tartogay Vil. (12-15) and Zhankel' Vil. (16), and the male lectotype (17-21). (12, 17) Left bulbus, ventral view. (13, 20) Ditto, retrolateral view. (14, 19) Ditto, posterior view. (15, 16) Left male palp, retrolateral view. (18) Left bulbus, apical view. (21) Original data labels of the lectotype. Scale bars 0.5 mm (15, 16), 0.2 mm (12-14, 17-20). Abbreviations as explained in Material and methods.

22

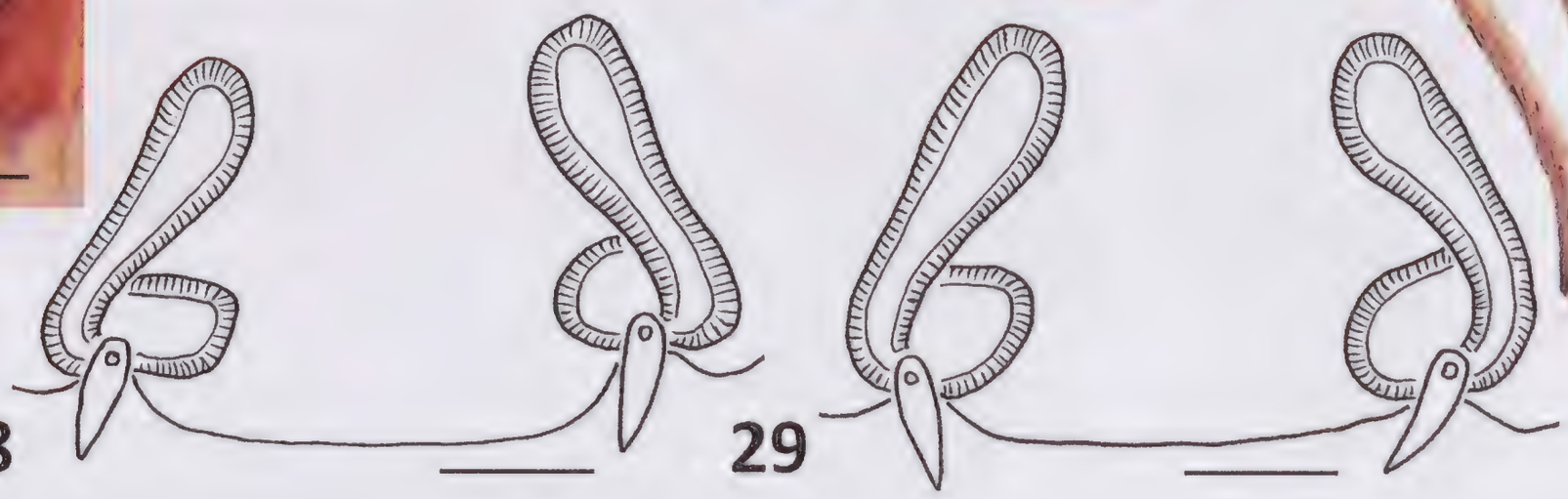
23

24

25

27

26


28 29

Figs 22-29. *Karakumosa alticeps* (Kroneberg, 1875); male (22-23) and female (24-28) from Chu river valley, and female (29) from Karamola Mt. (22, 24) Body, dorsal view. (23, 25) Ditto, ventral view. (26) Ditto, lateral view. (27) Epigyne, ventral view. (28-29) Vulva, dorsal view. Scale bars 1 cm (22-26), 0.25 mm (27-29).

wide marginal bands of white setae. Sternum brownish yellow, densely covered with white setae. Maxillae and labium brown. Chelicerae dark brown, proximal half of frontal side densely covered with yellowish white setae. Abdomen: dorsum densely covered with yellowish white setae and with a large, wide, brownish cardiac mark; sides and venter, including book-lung covers, densely covered with white setae. Spinnerets light brown. All legs and palps yellow, densely covered with white setae; tarsi of all legs and palps darker (brownish). Palps with a single claw at their tips.

Epigyne and vulva (Figs 27-29): Epigynal atrium twice as long as wide, markedly narrower at its anterior end and with only slightly sigmoid lateral edges; posterior transverse plate narrow and slightly procurved; spermathecae tube-shaped, not incrassate, directed antero-mediad, inclined towards each other.

Comments: The original type series of *Tarentula alticeps*, deposited in the ZMMU, consists of two species. Two syntype males (Ta-1218 and Ta-1219) were collected from today's southern Kazakhstan and are conspecific. In order to stabilize the species-group name *Tarentula alticeps*, one of them (Ta-1219; Figs 17-21) is here designated as the lectotype. Both males are conspecific with those collected from southern Kazakhstan together with females in the last two decades (see above under 'Other material'). Thus, there is no doubt about matching the sexes in this species.

The female paralectotype (Figs 165, 168) and juveniles of *Tarentula alticeps* were collected from present-day Uzbekistan (Ulus and Samarkand). This adult female differs from those of *K. alticeps* in having a much wider epigynal atrium (Fig. 168 cf. Fig. 27) and subparallel spermathecae (convergent in *K. alticeps*; Fig. 166 cf. Fig. 28). This female conforms to the description of *K. turanica* sp. nov. from Turkmenistan (see below; Figs 166-167). Hence, we assign the female paralectotype of *Tarentula alticeps* and its Uzbekistani records (Fig. 155) to *K. turanica* sp. nov.

Moreover, the immature syntypes of *T. alticeps* examined (Ta-1216) contain specimens of two different genera. One immature female has a brown, contrastingly coloured venter, which is typical of *Allohogna* Roewer, 1955a, *Lycosa* (*s.str.*), *Zyuzicosa* and some other burrowing wolf spiders, but that was never observed in *Karakumosa* gen. nov. It is additional evidence that the original type series of *Tarentula alticeps* is indeed not conspecific.

Distribution: Southern Kazakhstan (Kroneberg, 1875; Zyuzin *et al.*, 1994; present data) (Fig. 76); all the known records of *K. alticeps* lie in the same South-Turkestan Phytogeographic Province (see Pravdin, 1978 for further details). At one of the localities examined (Karamola Mt.), *K. alticeps* was found together with another large burrowing wolf spider, *Zyuzicosa turlanica* Logunov, 2010; see Logunov (2010, 2012) for further details about the latter species and its records.

Many of the earlier records of *K. alticeps* are in need of confirmation by re-examining the corresponding material, which was not available for the present study. For instance, the records from Uch-Adzhi (c. 38°05'N, 62°48'E) and Turkmenbashi (c. 40°02'N, 52°59'E) in Turkmenistan by Schmidt (1895: sub. *Lycosa alticeps*) most likely belong to *K. turanica* sp. nov., while his record from the Fergana region of Uzbekistan (no exact locality) could belong to *K. tashkumyr* sp. nov. The records of *K. alticeps* from Tajikistan (Kondara, Kvak, Varzob Canyon, Hissar Mt. Range, Ramit, Gandzhina) by Andreeva (1975, 1976: sub *Lycosa alticeps*) are likely based on misidentifications. To date we have been able to re-examine only two samples from Tajikistan that are deposited in the ZMMU (Ta-2916: 1 male from Kondara; Ta-2915: 3 females, 4 juveniles from Yavan-su Vil.) and earlier identified by Jan Buchar as *Lycosa alticeps*. Both samples turned out to be misidentified and in fact belong to *Zyuzicosa laetabunda* (Spassky, 1941).

Karakumosa badkhyzica sp. nov.

Figs 30-48, 76

Lycosa alticeps (Kroneberg, 1875). – Ovtsharenko & Fet, 1980: 443. – Mikhailov & Fet, 1994: 508 (misidentification of specimens from Badkhyz).

Holotype: ISEA; male; TURKMENISTAN, Mary Velayat, c. 73 km NW of Serhetabat (= Kushka), Badkhyz (= Badhyz) Reserve (c. 35°52'N, 61°40'E), cordon Kyzyl-Dzhar, clay slope; 10.-14.IV.1993; leg. A.A. Zyuzin.

Paratypes: ISEA; 3 females; collected together with the holotype. – ZMMU; 1 male, 1 female; same data. – MMUE; 1 male, 1 female; same data.

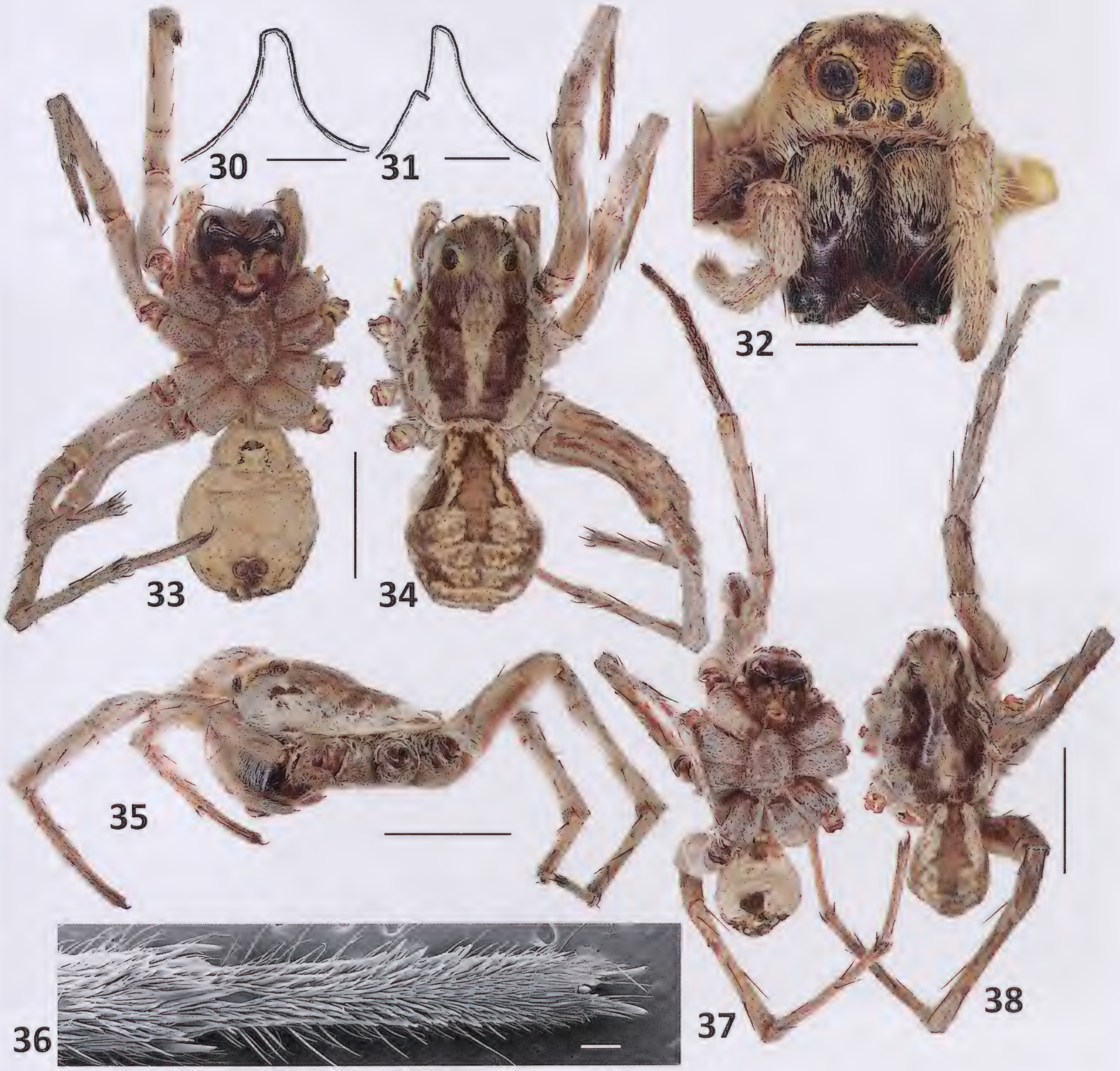
Etymology: The species epithet is latinized adjective derived from the name of the type locality, the Badkhyz (= Badhyz) Reserve in Turkmenistan.

Diagnosis: The male of *K. badkhyzica* sp. nov. is most similar to that of *K. repetek* sp. nov. (Figs 94, 98, 102), but differs in having a smaller and narrower proximal extension of the MA (wide, spade-shaped in *K. repetek* sp. nov.; Figs 40, 46 cf. Fig. 98) and an undivided, finger-shaped median tooth (bifurcated in *K. repetek* sp. nov.; Figs 30-31, 42 cf. Figs 97, 100). The female of this species is similar to that of *K. medica* (Figs 85-86), but can be readily distinguished by a shorter epigynal atrium (Fig. 44) and by the shape of the spermathecae: anteriorly markedly swollen in *K. badkhyzica* sp. nov. (Fig. 43), worm-shaped, anteriorly not swollen in *K. medica* (Fig. 86).

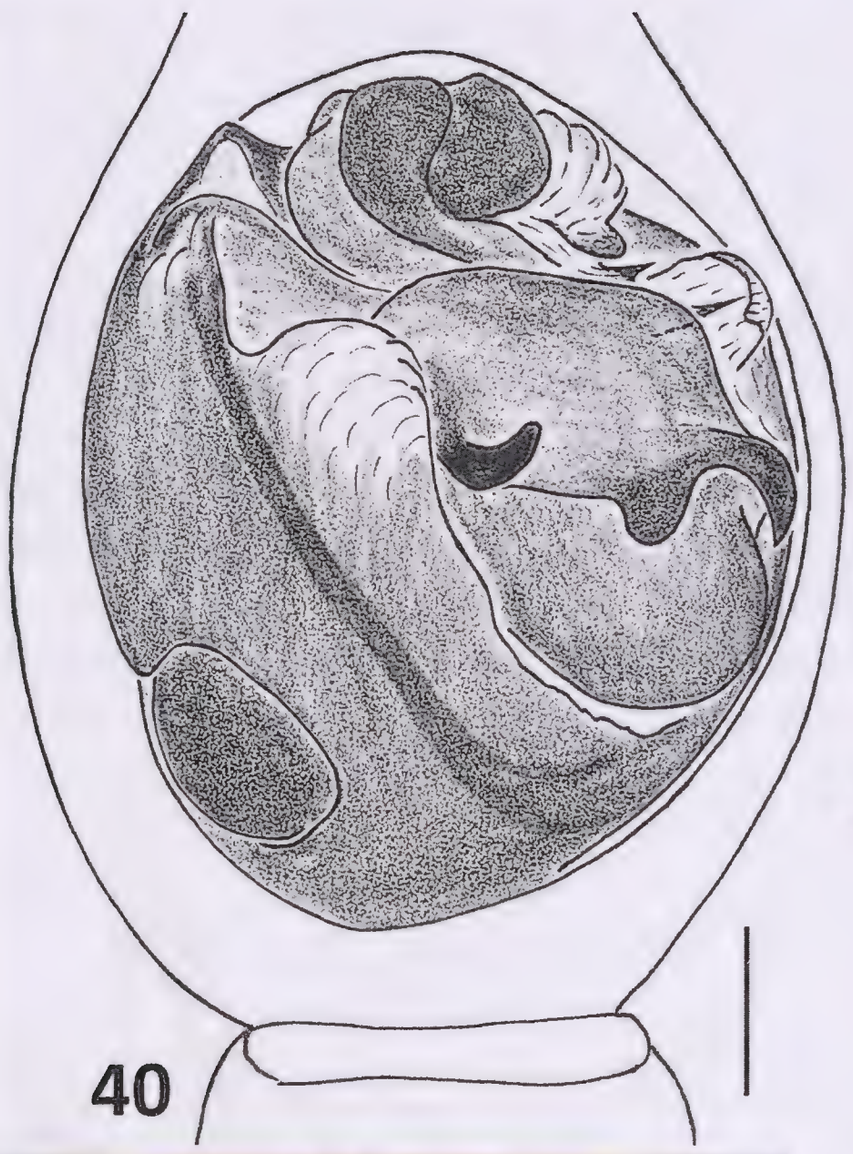
Description: Male (paratype, MMUE). *Measurements*: Carapace 7.65 long, 4.50 wide. Eye sizes and interdistances: AME 0.40, ALE 0.34, PME 0.68, PLE 0.75, AME-AME 0.20, AME-ALE 0.10, PME-PME

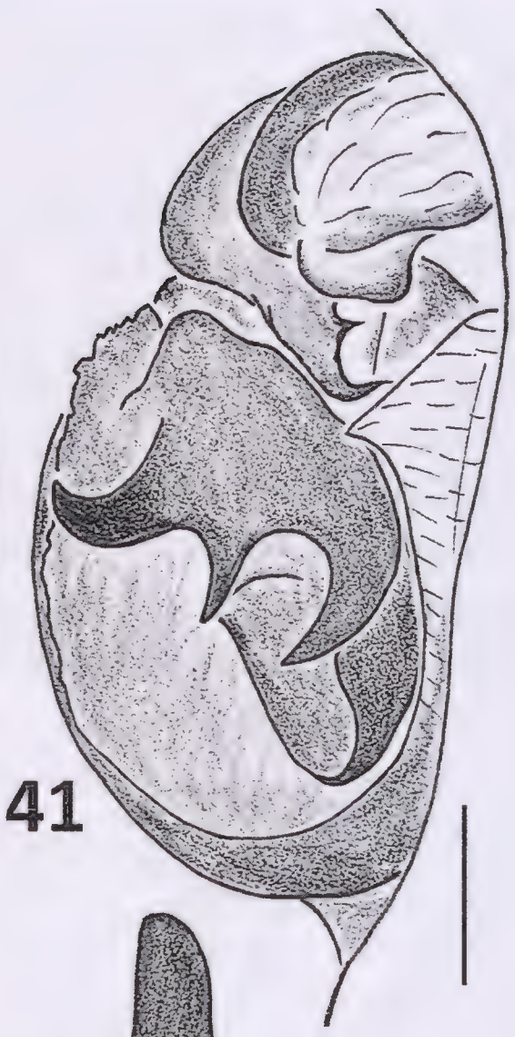
0.80 PME-PLE 0.85. Width of anterior eye row 1.63, of second row 2.30, of third row 2.20. Clypeus height 0.10; chelicera length 2.75. Abdomen 5.75 long, 3.25 wide. Length of leg segments: I 8.20 + 3.30 + 7.10 + 7.20 + 4.40 (30.20); II 7.80 + 3.40 + 6.20 + 7.50 + 3.70 (28.60); III 7.40 + 3.00 + 5.30 + 8.00 + 3.90 (27.60); IV 8.50 + 3.20 + 7.00 + 9.80 + 4.50 (33.00). Leg formula: IV, I, II, III.

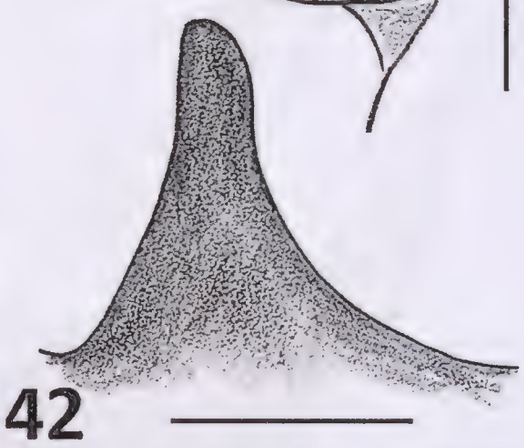
Colouration in alcohol (Figs 37-38): Carapace brownish, with a wide median longitudinal yellowish white band of setae along entire length of carapace and with two wide lateral brown longitudinal bands of setae; carapace sides with wide marginal bands of white setae. Sternum light brown, densely covered with white setae. Maxillae and labium brownish, with yellow tips. Chelicerae brown, proximal half of frontal side densely covered with white setae. Abdomen: dorsum densely covered with white setae, with a long, wide, yellow-brown cardiac mark; sides and venter densely covered with white setae. Book-lung covers yellow, covered with white setae. Spinnerets brown. All legs yellow, densely covered with white setae; Mt I and Tr I brown, also densely covered with white setae. Palp yellow, with the brownish cymbium, densely covered with white setae.

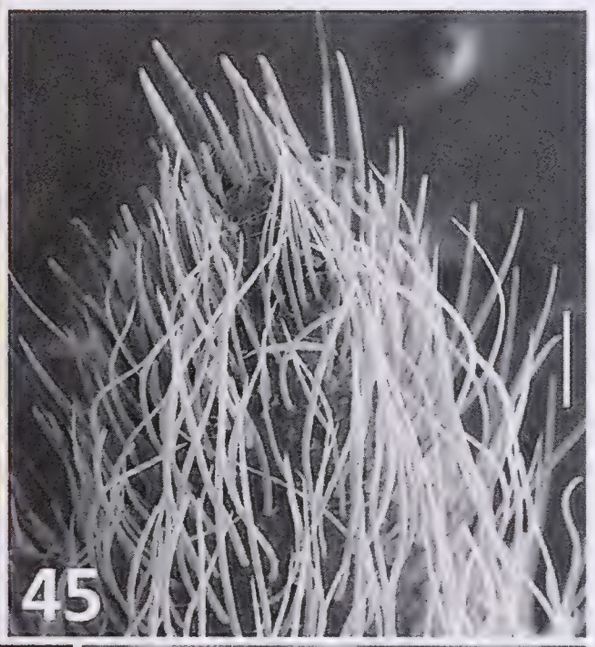


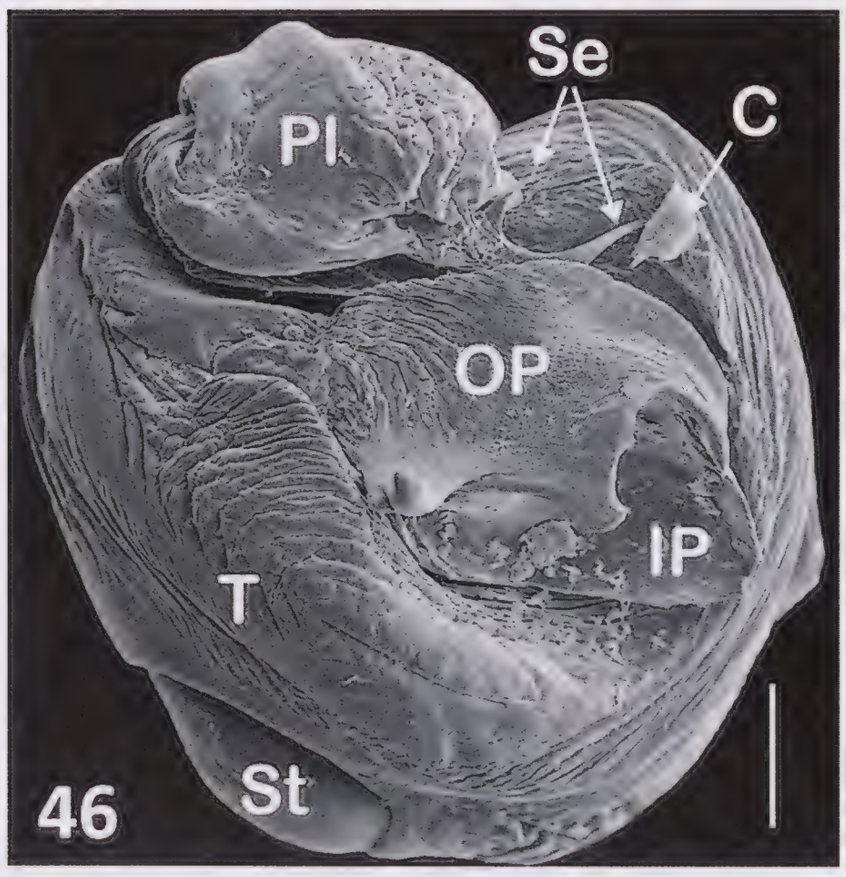
Figs 30-38. *Karakumosa badkhyzica* sp. nov.; male paratype (30-31, 37-38) and female paratype (32-35), MMUE. (30-31) Median tooth of MA, posterior view. (32) Female prosoma, frontal view. (33, 37) Body, ventral view. (34, 38) Ditto, dorsal view. (35) Female prosoma, lateral view. (36) Female tarsus I, ventral view. Scale bars 0.5 cm (33-35, 37-38), 0.3 mm (36), 0.25 cm (32), 0.1 mm (30, 31).











Figs 39-48. *Karakumosa badkhyzica* sp. nov.; male paratype, MMUE (39-42), male holotype (45-48) and female paratype (43-44). (39-40, 46) Bulbus, ventral view. (41) Ditto, retrolateral view. (42, 48) Median tooth of MA, posterior view. (43) Vulva, dorsal view. (44) Epigyne, ventral view. (45) Cymbium tip, dorsal view. (47) Bulbus, apical view. Scale bars 0.5 mm (39, 44), 0.25 mm (40-41, 43), 0.2 mm (45-47), 0.1 mm (42), 0.05 mm (48). Abbreviations as explained in Material and methods.

Palp structure (Figs 30-31, 39-42, 45-48): Acutely pointed synembolic lamellae diverging from each other; median tooth finger-shaped, in some specimens with a basal tooth; proximal extension narrow, spatula-like; inner plate large, with an extended retrolateral shoulder; conductor triangular, pointed at its tip.

Female (paratype, MMUE). *Measurements*: Carapace 8.70 long, 6.50 wide. Eye sizes and interdistances: AME 0.45, ALE 0.38, PME 0.88, PLE 0.95, AME-AME 0.25, AME-ALE 0.15, PME-PME 0.93, PME-PLE 1.20. Width of anterior eye row 1.93, of second row 2.68, of third row 3.30. Clypeus height 0.30; chelicera length 4.35. Abdomen 8.76 long, 6.40 wide. Length of leg segments: I 6.60 + 3.20 + 4.90 + 4.50 + 2.80 (22.00); II 6.50 + 3.20 + 4.30 + 4.30 + 2.70 (21.00); III 5.30 + 2.50 + 3.60 + 5.10 + 2.80 (19.30); IV 7.50 + 3.00 + 5.30 + 6.70 + 3.50 (26.00). Leg formula: IV, I, II, III.
Colouration in alcohol (Figs 32-35): Carapace yellow-brown, densely covered with white setae and with two paramedian longitudinal bands of brown setae. Sternum brownish yellow, densely covered with white setae. Maxillae and labium brown, with yellow tips. Chelicerae dark brown, proximal half of frontal side densely covered with yellowish white setae. Abdomen: dorsum densely covered with white setae, with a large, wide, brownish cardiac mark and with a brownish pattern of transverse lines; sides and venter, including book-lung covers, densely covered with white setae. Spinnerets brownish. All legs and palps yellow, densely covered with white setae; tarsi of all legs darker (brownish). Palps with a claw at their tips.
Epigyne and vulva (Figs 43-44): Epigynal atrium twice as long as wide, with lateral edges slightly biconvex; posterior transverse plate short, anchor-shaped; spermathecae tube-shaped, directed antero-mediad, inclined towards each other, distinctly swollen in anterior portion.

Distribution: Only known from the type locality, the Badkhyz Reserve in Turkmenistan (Fig. 76).

Habitat: This species occurs in sparse pistache woodland, with an undergrowth dominated by bulbous bluegrass (*Poa bulbosa*) and sedge (*Carex pachystylis*) (Ovtsharenko & Fet, 1980: sub *Lycosa alticeps*).

***Karakumosa gromovi* sp. nov.**
Figs 49-76

Holotype: ISEA; male; UZBEKISTAN, Surxondaryo Region, Baisun [= Boysun] Distr., c. 44 km SW of Denau [= Denov], SE foothills of Dzhetymkalyas Mt. Range (38°01'10.6"N, 67°28'06.3"E), c. 640 m. a.s.l.; 13.-14.V.1994; leg. A.V. Gromov.

Paratypes: ISEA; 1 female; collected together with the holotype. – ZMMU; 1 male, 1 female; same data. – MMUE; 1 male, 1 female; same data. – ISEA; 1 female; from the type locality; 14.V.1994; leg. A.V. Gromov & A.A. Zyuzin.

Etymology: This species is dedicated to our friend and colleague, Mr Alexander V. Gromov (Bingen-am-Rhein, Germany), who collected the type specimens.

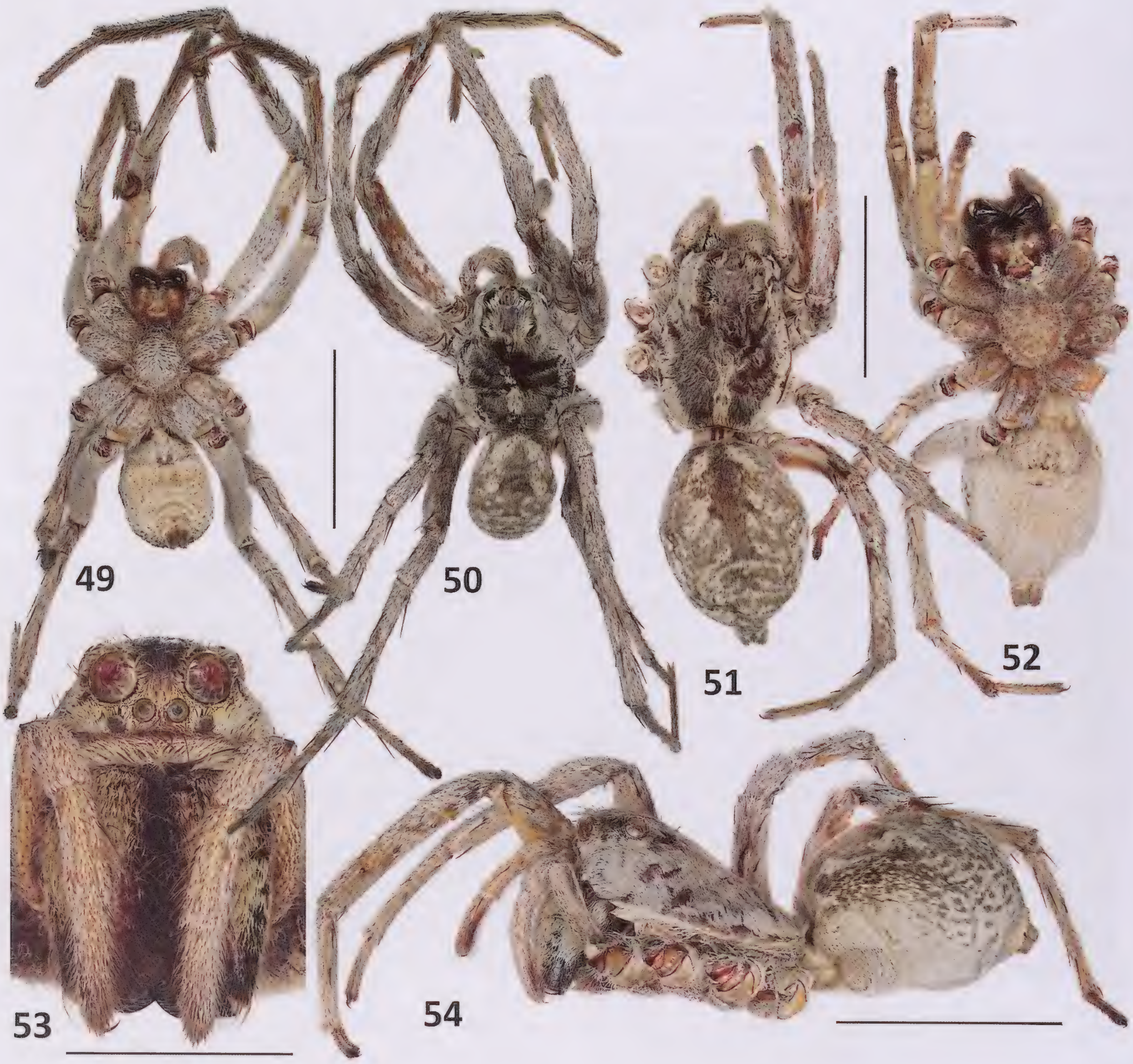
Diagnosis: In the hook-shaped proximal extension of the MA, the male of *K. gromovi* sp. nov. is most similar to males of *K. shmatkoi* sp. nov. (Figs 115-120) and *K. tashkumyr* sp. nov. (Figs 145-154), but can be readily distinguished by the absence of a low serrate flange at the foot of the median tooth (present in *K. tashkumyr* sp. nov.; Figs 74-75 cf. Figs 107-112 and Figs 152-154). In the straight, subparallel lateral edges of the epigynal atrium, the female of *K. gromovi* sp. nov. is most similar to that of *K. medica*, from which it can be distinguished by the triangular posterior transverse plate of the median septum and by the wider and shorter spermathecae (anchor-shaped posterior transverse plate and worm-shaped spermathecae in *K. medica*; Figs 61-62, 72-73 cf. Figs 85-86).

Description: Male (paratype in MMUE). *Measurements*: Carapace 9.50 long, 7.40 wide. Eye sizes and interdistances: AME 0.50, ALE 0.45, PME 1.20, PLE 1.00, AME-AME 0.20, AME-ALE 0.15, PME-PME 1.25, PME-PLE 1.50. Width of anterior eye row 2.00, of second row 2.80, of third row 3.50. Clypeus height 0.35; chelicera length 3.90. Abdomen 8.75 long, 6.25 wide. Length of leg segments: I 9.80 + 3.90 + 8.00 + 8.40 + 4.40 (34.50); II 9.40 + 3.90 + 7.50 + 8.80 + 4.00 (33.60); III 8.20 + 3.10 + 6.50 + 9.00 + 3.50 (30.30); IV 9.80 + 3.50 + 8.50 + 11.50 + 4.70 (38.00). Leg formula: IV, I, II, III.
Colouration in alcohol (Figs 49-50): Carapace brown, densely covered with white setae, with two wide longitudinal bands of yellow brownish setae. Sternum brownish yellow, densely covered with white setae. Maxillae and labium orange-coloured, with yellow tips. Chelicerae brown, proximal half of frontal side and lateral sides densely covered with white setae. Abdomen: dorsum densely covered with white setae, with a wide, yellow brownish cardiac mark and with a pattern consisting of yellow brownish transverse stripes and patches; sides and venter densely covered with white setae. Book-lung covers yellow, densely covered with white setae. Spinnerets yellowish grey. All legs brownish yellow, densely covered with white setae; Mt I-II and Tr I-II darker (brownish), also densely covered with white setae. Palp yellow, with brownish cymbium, densely covered with white setae.
Palp structure (Figs 55-60, 64-69, 74-75): Acutely pointed synembolic lamellae subparallel to each other; median tooth markedly bifurcated; proximal extension wide and markedly hook-shaped; distance between proximal extension and median tooth short, equal to

width of proximal extension; inner plate transverse, with an extended, obtuse retrolateral shoulder; conductor triangular, obtuse at its tip.

Female (paratype in MMUE). *Measurements*: Carapace 12.00 long, 7.80 wide. Eye sizes and interdistances: AME 0.55, ALE 0.45, PME 1.30, PLE 1.20, AME-AME 0.25, AME-ALE 0.18, PME-PME 1.50, PME-PLE 1.70. Width of anterior eye row 2.00, of second row 3.15, of third row 4.00. Clypeus height 0.40; chelicera length 6.00. Abdomen 12.60 long, 9.40 wide. Length of leg segments: I 8.90 + 3.90 + 6.80 + 6.00 + 3.10 (28.70); II 8.90 + 3.80 + 6.10 + 6.00 + 3.00 (27.80); III 6.70 + 2.90 + 5.20 + 6.30 + 2.90 (24.00); IV 8.50 + 3.50 + 6.90 + 8.00 + 3.80 (30.70). Leg formula: IV, I, II, III.

Colouration in alcohol (Figs 51-54, 70-71): Carapace brown, densely covered with white setae and with a well-marked pattern of two wide yellowish brownish longitudinal paramedian bands. Sternum yellow, densely covered with white setae. Maxillae and labium brown, with yellow tips. Chelicerae dark brown, proximal half of frontal side and lateral sides densely covered with yellowish white setae. Abdomen: dorsum densely covered with white setae, with a brownish cardiac mark and a pattern consisting of brownish transverse stripes,



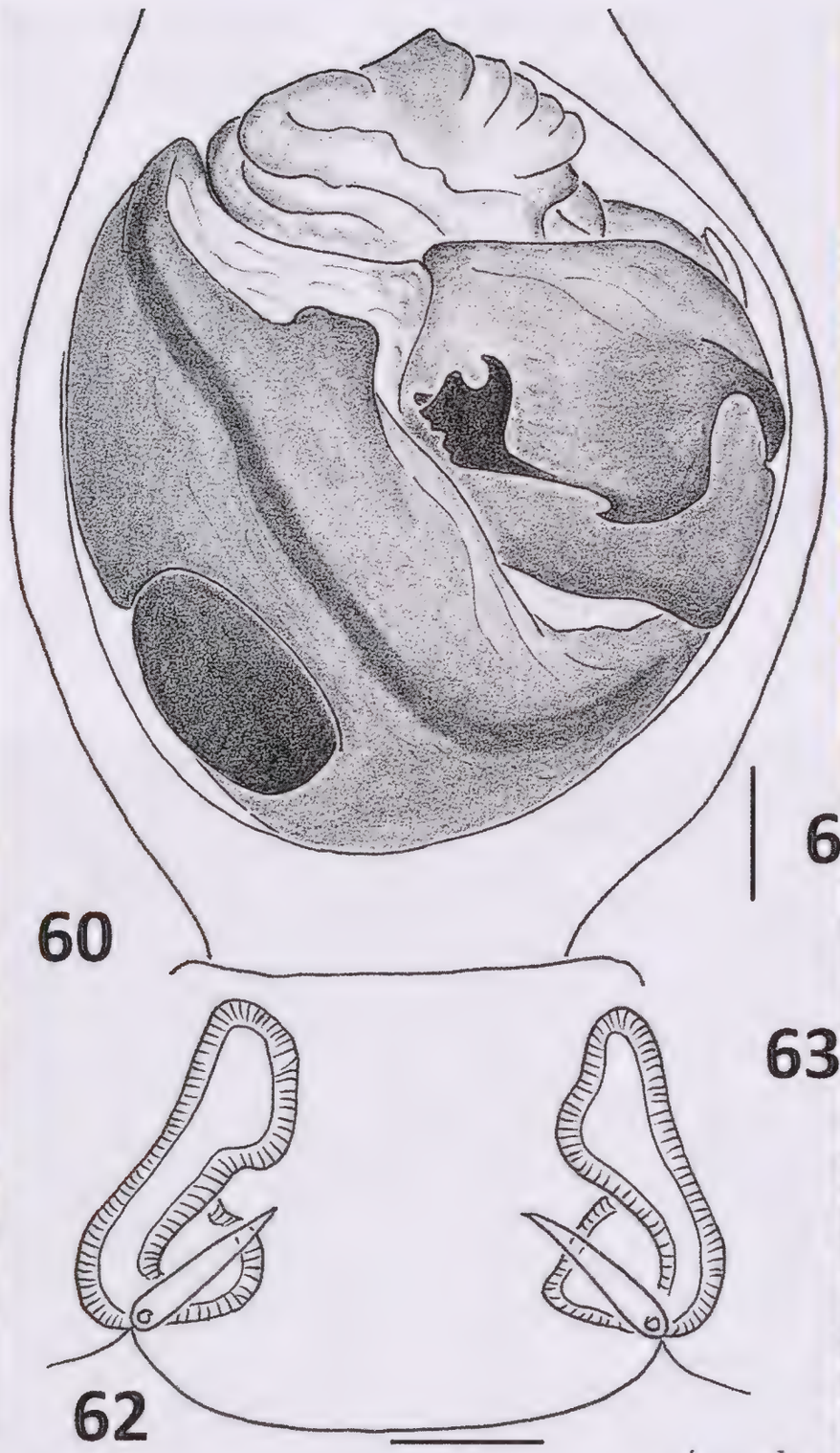
Figs 49-54. *Karakumosa gromovi* sp. nov.; male paratype (49-50) and female paratype (51-54). (49, 52) Body, ventral view. (50-51) Ditto, dorsal view. (53) Female prosoma, frontal view. (54) Female body, lateral view. Scale bars 1 cm (49-52, 54), 0.5 cm (53).

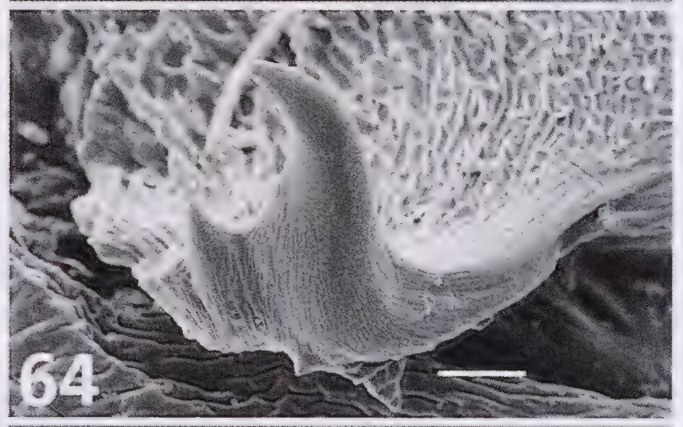
patches and speckles; sides and venter yellow, densely covered with white setae. Book-lung covers yellow, densely covered with white setae. Spinnerets greyish yellow. All legs yellow brownish, densely covered with white setae. Palp yellow brownish, densely covered with white setae, with a tarsal claw.

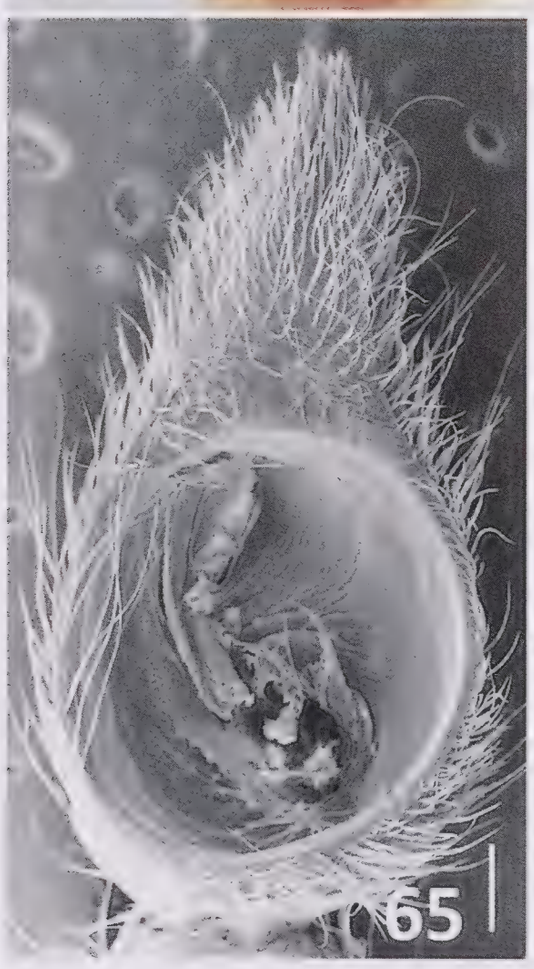
Epigyne and vulva (Figs 61-62, 72-73): Epigynal atrium twice as long as wide, with straight subparallel lateral edges; posterior transverse plate markedly triangular, its posterior margin angular; spermathecae pear-shaped, their tips directed medio-anteriad, inclined towards each other.

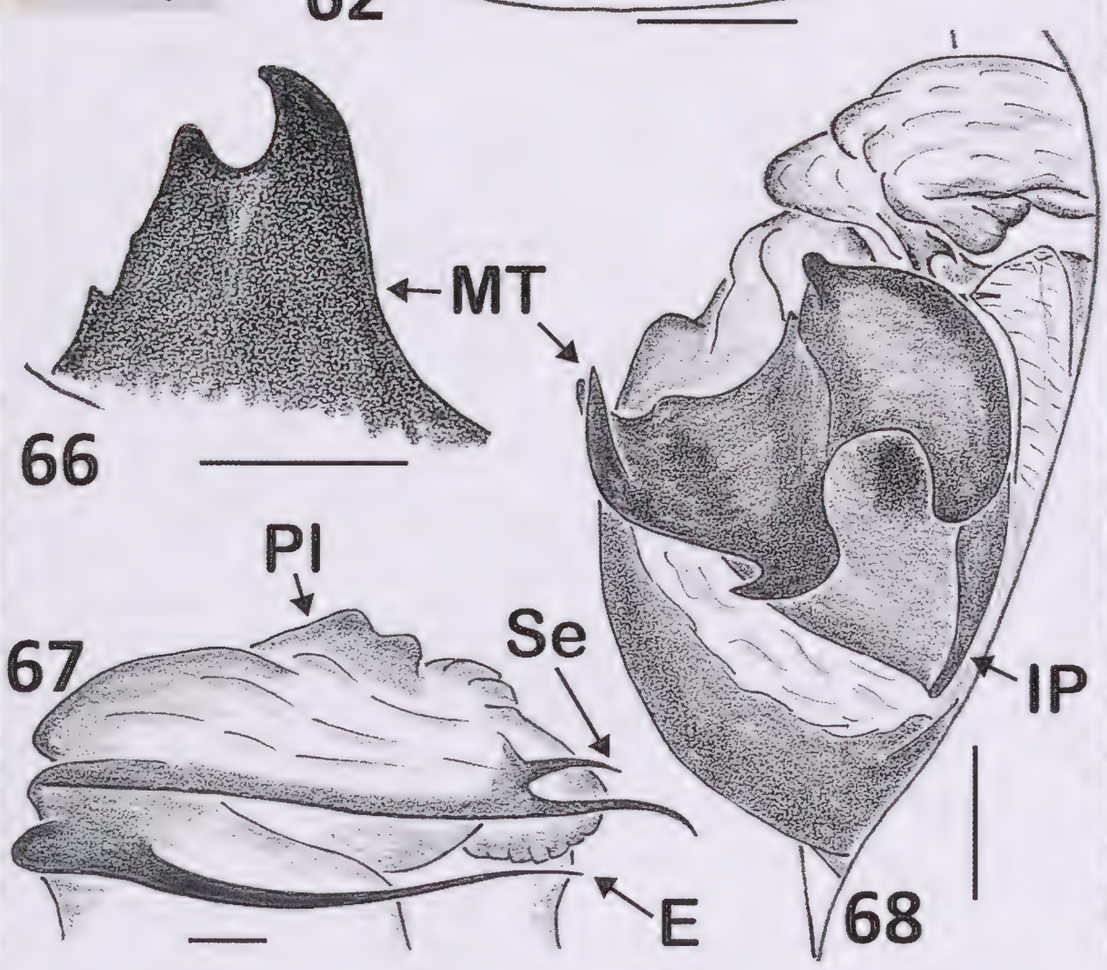
Distribution: Only known from the type locality in southern Uzbekistan (Fig. 76) where this species occurs together with another large burrowing wolf spider: *Zyuzicosa baisunica* Logunov, 2010; see Logunov (2010) for further information on the latter species.

Figs 55-58. *Karakumosa gromovi* sp. nov., bulbus of male paratype. (55) Ventral-retrolateral view. (56) Ventral view. (57) Apical view. (58) Retrolateral view. Scale bars 0.2 mm. Abbreviations as explained in Material and methods.

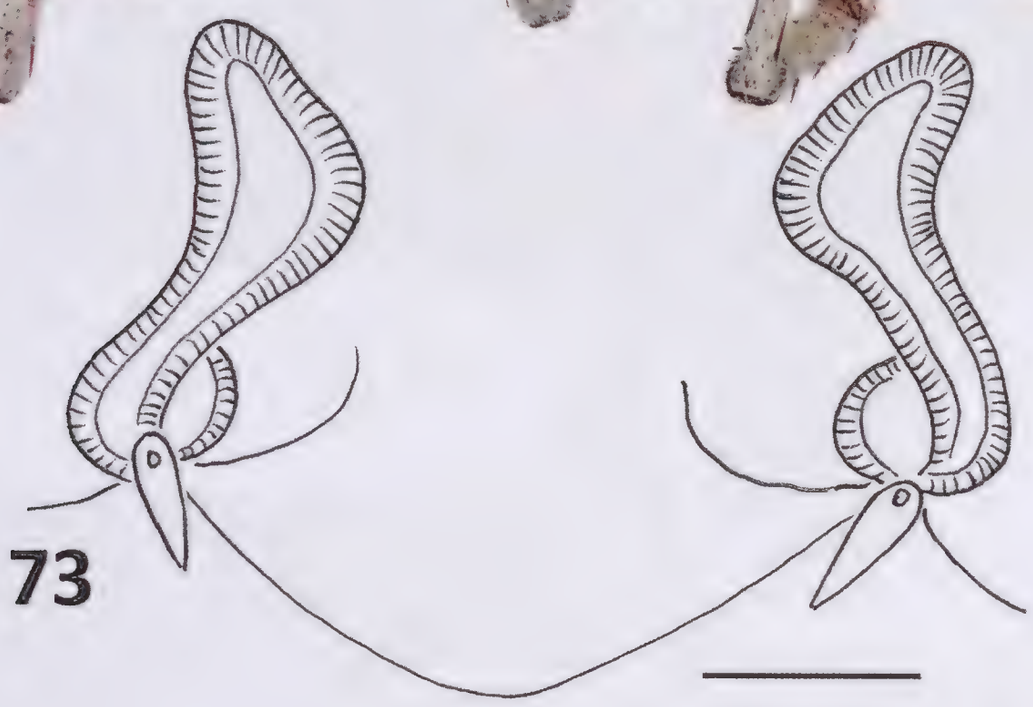


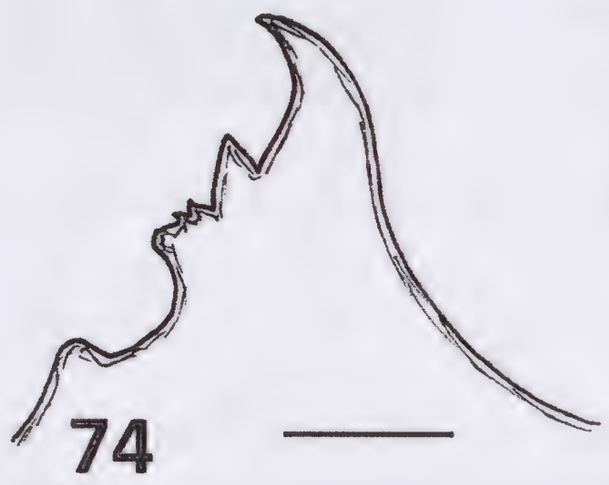


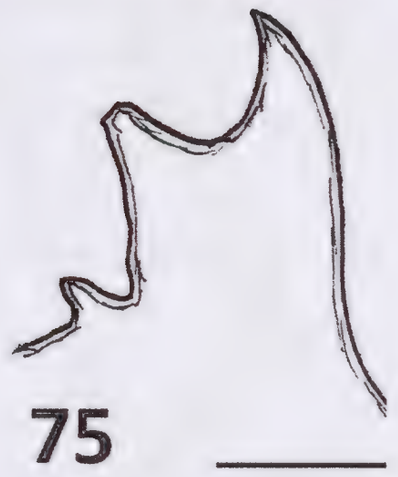




Figs 59-69. *Karakumosa gromovi* sp. nov.; male paratypes (59-60, 64-69) and paratype female (61-63). (59-60) Bulbus, ventral view. (61) Epigyne, ventral view. (62) Vulva, dorsal view. (63) Female tarsus I, ventral view. (64, 66) Median tooth of MA, posterior view. (65) Cymbium, ventral view. (67) Embolic division, ventral view. (68) Bulbus, retrolateral view. (69) Cymbium tip, dorsal view. Scale bars 0.5 mm (59, 61), 0.3 mm (63, 65), 0.25 mm (62), 0.1 mm (60, 66-69), 0.05 mm (64). Abbreviations as explained in Material and methods.







Figs 70-75. *Karakumosa gromovi* sp. nov.; male paratypes (74-75) and female paratype (70-73). (70) Body, dorsal view. (71) Ditto, ventral view. (72) Epigyne, ventral view. (73) Vulva, dorsal view. (74-75) Median tooth of MA, posterior view. Scale bars 1 cm (70-71), 0.5 mm (72), 0.25 mm (73), 0.1 mm (74-75).

Karakumosa medica (Pocock, 1889) comb. nov.

Figs 76-88

Tarentula medica Pocock, 1889: 110, pl. 13, figs 1a-g (description of male and female; 1 adult male, 1 adult female and 1 immature syntypes in the BMNH).

Hogna media. – Roewer, 1955b: 249 (misspelling).

Lectotype (designated here): BMNH, BM 1887.51; male; AFGHANISTAN, Meshed/Tirp-hul ['Kalla-idast-dargarri'; c. 34°42'N, 61°03'E]; no date [apparently June 1884]; leg. [J.E.T.] Aitchison.

Paralectotypes: BMNH, BM 1887.51; 1 female, 1 immature; collected together with the lectotype.

Etymology: Although the author (Pocock, 1889) did not explain the origin of the name, the species epithet presumably is the Latin adjective 'medicus, -a, -um' (= medical), likely referring to the fear of this spider expressed by local people; see under 'Comments' below.

Diagnosis: This species is similar to *K. badkhyzica* sp. nov. (Figs 39-48), but differs in having a wider proximal extension of the MA (Fig. 83), a longer epigynal atrium (Fig. 85) and a different conformation of the spermathecae: worm-shaped in *K. medica* (Fig. 86) and markedly swollen anteriorly in *K. badkhyzica* sp. nov. (Fig. 43). See also comments above under 'Diagnosis' of *K. gromovi* sp. nov.

Description: Male (lectotype). *Measurements*: Carapace 13.00 long, 10.00 wide. Eye sizes and interdistances: AME 0.55, ALE 0.50, PME 1.30, PLE 1.25, AME-AME 0.30, AME-ALE 0.20, PME-PME 1.00, PME-PLE 2.45. Width of anterior eye row 2.50, of second row 3.40, of third row 4.20. Clypeus height 0.35; chelicera length 5.00. Abdomen 9.00 long, 6.40 wide. Length of leg segments: I 13.00 + 5.30 + 11.00 + 12.50 + 6.00 (47.80); II 12.60 + 5.30 + 10.50 + 12.50 + 5.50 (46.40); III 11.40 + 4.60 + 8.60 + 12.70 + 5.50 (42.80); IV 13.80 + 4.50 + 11.20 + 16.20 + 6.50 (52.20). Leg formula: IV, I, II, III.

Colouration in alcohol (Figs 81-82): Specimen damaged and shabby. Carapace dark russet, almost without white setae. Sternum orange-coloured, densely covered with white setae. Maxillae orange-coloured. Labium orange-

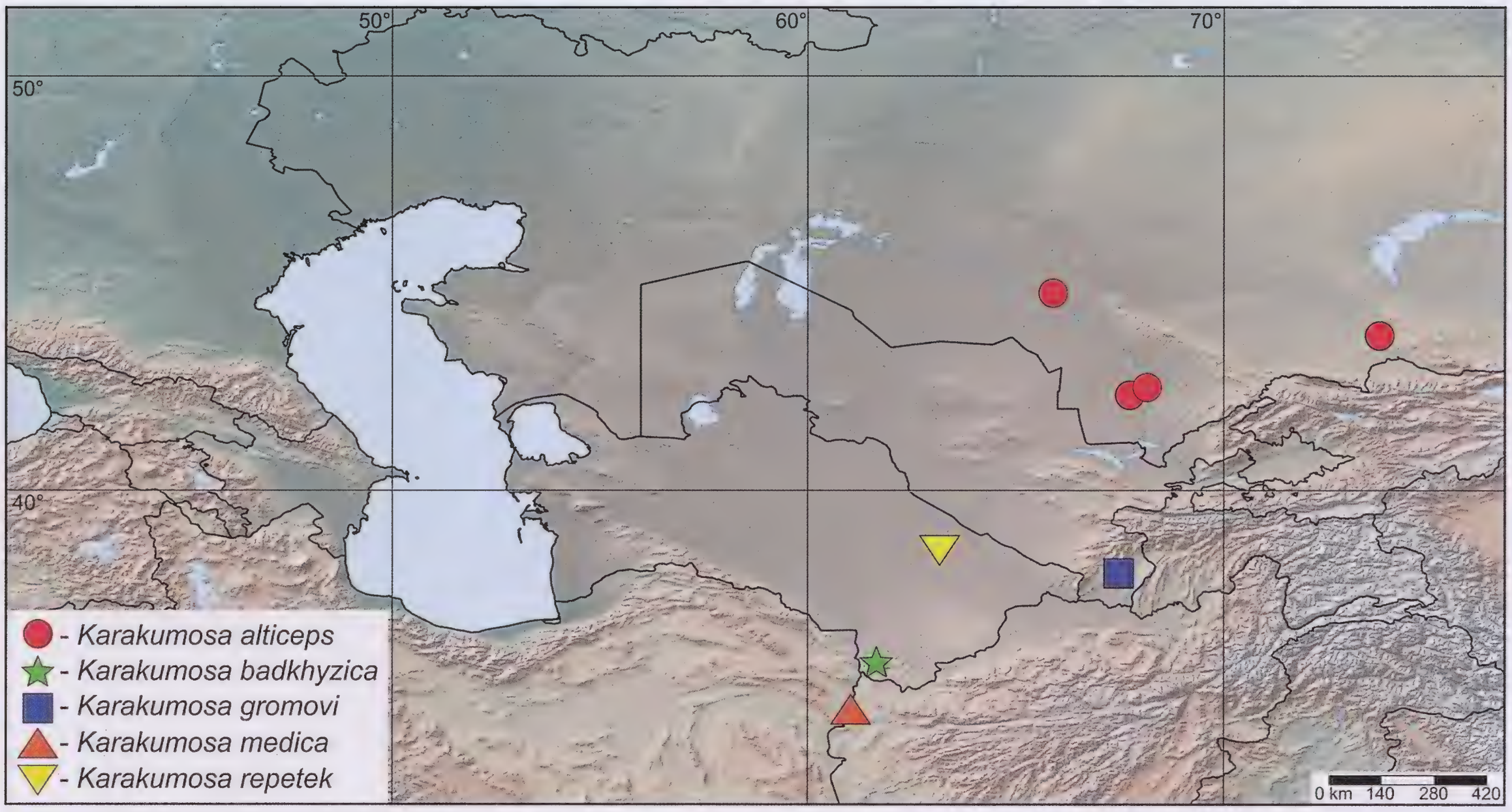


Fig. 76. Localities of five species in the genus *Karakumosa* gen. nov.

coloured, with a yellow tip. Chelicerae dark brown, their frontal sides covered with white setae. Abdomen: dorsum densely covered with white setae, with a yellow cardiac mark outlined by a brown line; sides and venter densely covered with yellowish white setae. Book-lung covers orange-coloured, densely covered with yellowish white setae. Spinnerets brown. All legs orange-coloured brownish, densely covered with white setae. Palps orange-coloured, densely covered with white setae.

Palp structure (Figs 83-84, 87-88; mirrored image of right palp): Acutely pointed synembolic lamellae slightly convergent towards each other; medina tooth markedly bifurcated; proximal extension wide and relatively short; inner plate transverse-ovoid; conductor triangular, pointed at its tip.

Female (paralectotype). *Measurements*: Carapace 14.70 long, 11.00 wide. Eye sizes and interdistances: AME 0.70, ALE 0.55, PME 1.70, PLE 1.20, AME-AME 0.35, AME-ALE 0.25, PME-PME 1.10, PME-PLE 3.10. Width of anterior eye row 3.00, of second row 4.25, of third row 5.10. Clypeus height 0.65; chelicera length 6.50. Abdomen 13.00 long, 9.50 wide. Length of leg segments: I 12.30 + 5.00 + 9.50 + 9.00 + 4.70 (40.50); II 11.50 + 5.30 + 8.80 + 9.20 (no segment) (?); III 10.30 + 5.20 + 7.40 + 9.50 + 5.20 (37.70); IV 13.30 + 5.50 + 9.80 + 13.00 + 6.10 (47.70). Leg formula: IV, I, II, III.

Colouration in alcohol (Figs 77-80): Specimen damaged and shabby. Carapace dark russet, almost without white setae. Sternum orange-coloured, densely covered with white setae. Maxillae brownish orange-coloured. Labium brown-orange-coloured, with a yellow tip. Chelicerae dark brown, proximal part of frontal side and lateral sides covered with yellowish white setae. Abdomen damaged: dorsum densely covered with yellowish white setae, with no visible cardiac mark and colour pattern; sides and venter yellow, densely covered with yellowish white setae. Book-lung covers yellow, densely covered with yellowish white setae. Spinnerets brown. All legs orange-coloured, densely covered with yellowish white setae. Palps orange-coloured, densely covered with white setae.

Epigyne and vulva (Figs 85-86): Epigynal atrium three times as long as wide, with subparallel lateral edges; posterior transverse plate short, its posterior margin slightly bent (making the plate anchor-shaped); spermathecae tube-shaped, bent mediad and then directed anteriad.

Comments: In the original paper (Pocock, 1889: 111), the particulars of collecting the *Tarentula medica* types are described as follows: "…taken between Tirphul and Meshed in Persia". Later in the text, based on the collector's observations (J.E.T.A.), Pocock (1889) added that "At Kalla-idast-dargarri, June 8th, amongst the brick debris of the old buildings, and running in and out of the clay fissures in the soil, this spider occurred in large numbers, much to the horror of the natives - the Afghans and Persians holding it in great fear, as, they say, should it drop any of its excreta on the skin,

Figs 77-82. *Karakumosa medica* (Pocock, 1889); female paralectotype (77-80) and male lectotype (81-82). (77, 81) Body, dorsal view. (78) Ditto, lateral view. (79) Prosoma, frontal view. (80, 82) Body, ventral view. Scale bars 1 cm (77-78, 80-82), 0.5 cm (79).

the result is acute erysipelas, usually ending in death". Based on the map published by the Afghan Delimitation Commission (Aitchison, 1889), 'Kalla-idast-dargarri' seems to be a site lying some 14 km WNW of the present-day Kohsān, on the left bank of the Hari River in the Herat Province of Afghanistan (c. 34°42'N, 61°03'E). This site is here accepted as the type locality of *Tarentula medica*. We failed to find the geographic name 'Kalla-idast-dargarri' on contemporary maps.

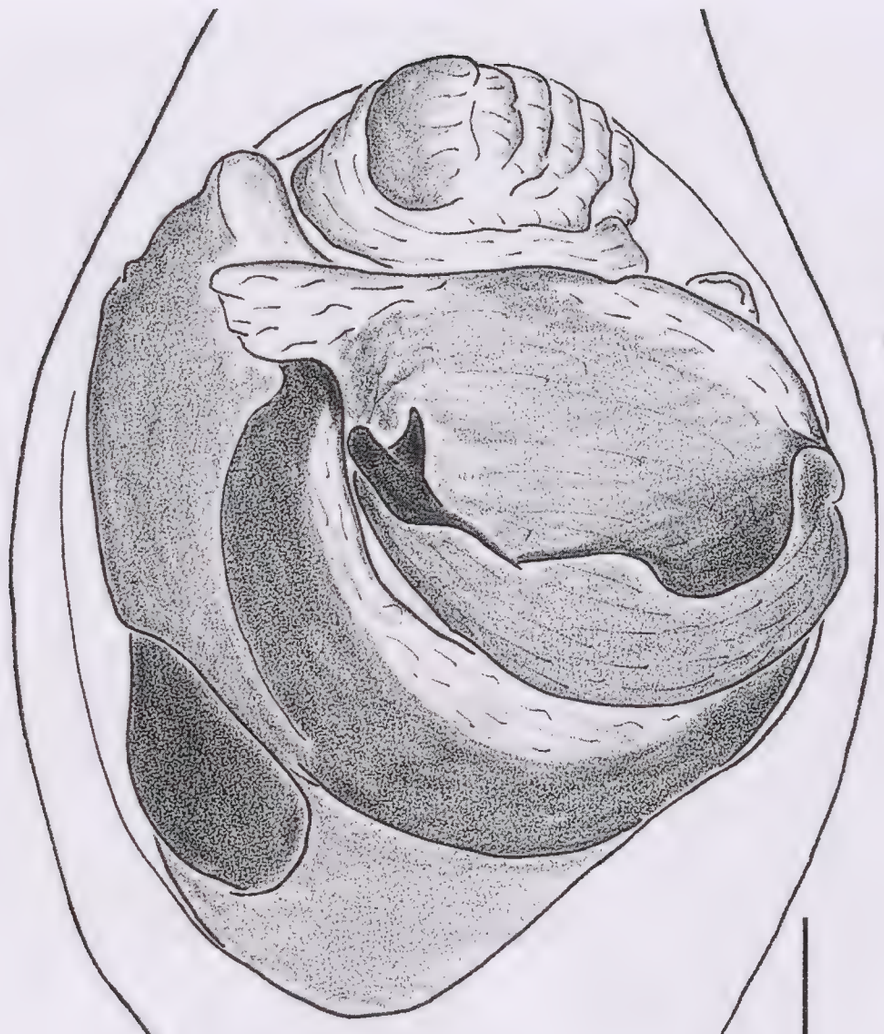
Distribution: Only known from the type locality in north-western Afghanistan (Fig. 76). The record of this species by Schmidt (1895: 450; sub. *Lycosa medica*) from Uzbekistan, Qarshi (= Karschi; c. 38°51'N, 65°47'E) is doubtful and needs verification, because it more likely can be attributed to either *K. alticeps* or *K. gromovi* sp. nov. Unfortunately the whereabouts of Schmidt's specimens is unknown and they may be lost.

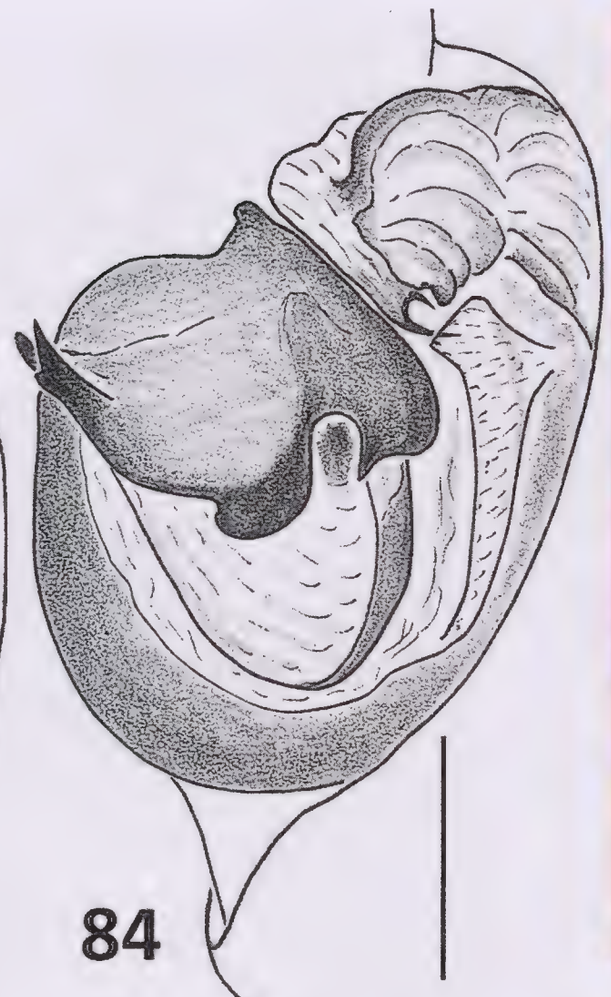
Karakumosa repetek sp. nov.

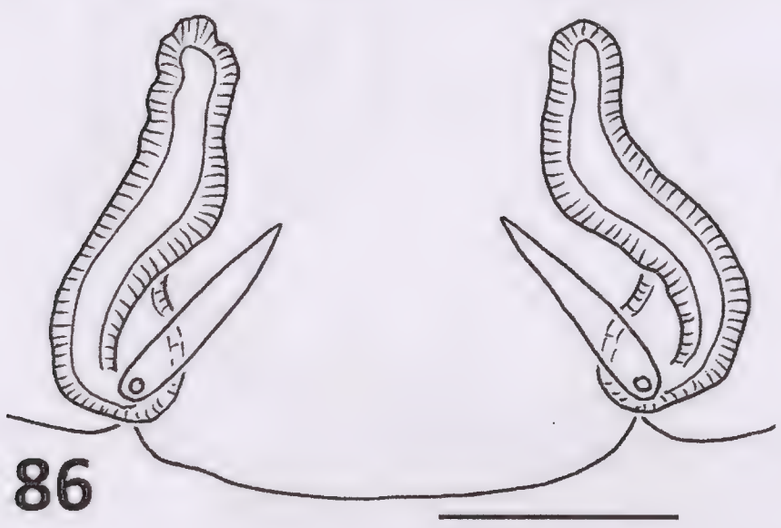
Figs 76, 89-102

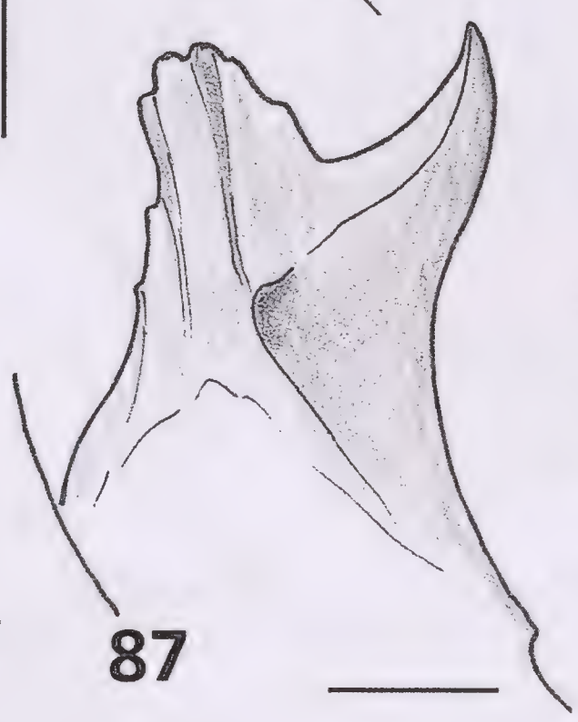
Holotype: ISEA, 001.4309; male; TURKMENISTAN, Repetek (c. 38°35'N, 63°11'E), on light near a house; 7.VIII.1972; leg. G.T. Kuznetsov.

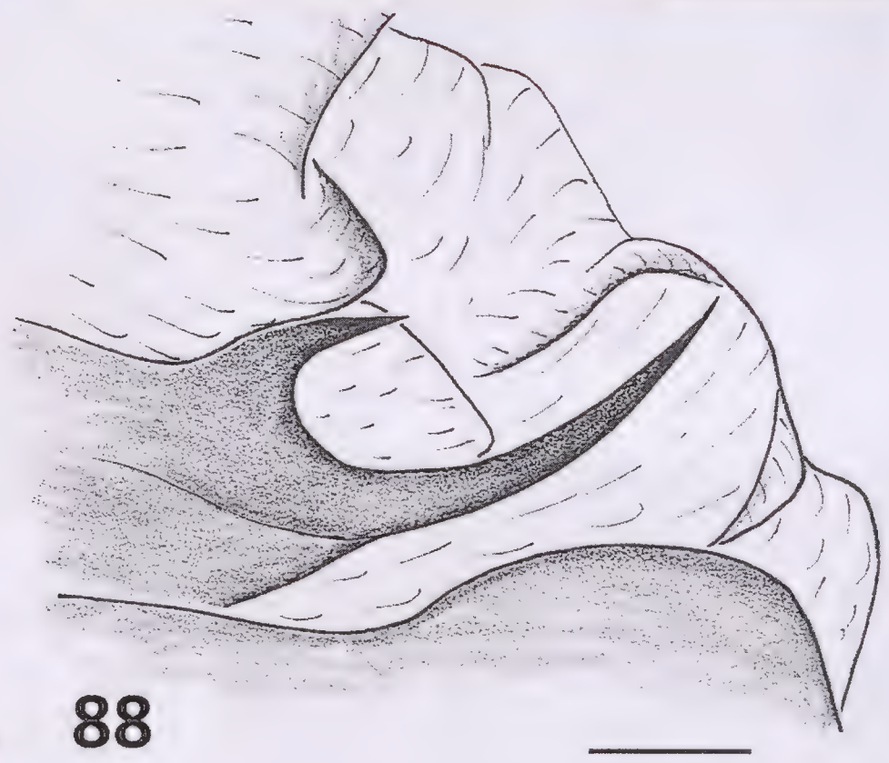
Paratypes: ISEA, 001.4310; 2 males; from the type locality; 31.VIII.1972; leg. G.T. Kuznetsov. – ISEA, 001.4213; 1 female; from the type locality; 21.VII.1985; leg. V.Ya. Fet.











Figs 83-88. *Karakumosa medica* (Pocock, 1889); male lectotype (83-84, 87-88) and female paralectotype (85-86). (83) Bulbus, ventral view. (84) Ditto, retrolateral view. (85) Epigyne, ventral view. (86) Vulva, dorsal view. (87) Median tooth of MA, posterior view. (88) Synembolus, apical view. Scale bars 0.5 mm (83-86), 0.1 mm (87-88).

Etymology: The species epithet is a noun in apposition referring to the name of the type locality, the Repetek Reserve in Turkmenistan.

Diagnosis: The male of *K. repetek* sp. nov. is most similar to that of *K. badkhyzica* sp. nov. (Figs 40-42, 46-48), but differs in having a longer and wider, spade-like proximal extension of the MA (Fig. 98) and a bifurcated median tooth (spatula-like proximal extension and finger-like median tooth in *K. badkhyzica* sp. nov.; Fig. 42 cf. Fig. 100). In the slightly sigmoid lateral edges of the epigynal atrium, the female of *K. repetek* sp. nov. is most similar to that of *K. zyuzini* sp. nov., from which it differs in the shape of the posterior transverse plate (dumbbell-shaped *vs.* with straight posterior margin; Fig. 96 cf. Fig. 179) and in the curved *vs*. straight spermathecae (Fig. 95 cf. Fig. 182).

Description: Male (holotype). *Measurements*: Carapace 10.80 long, 8.00 wide. Eye sizes and interdistances: AME 0.50, ALE 0.38, PME 1.10, PLE 0.90, AME-AME 0.13, AME-ALE 0.10, PME-PME 0.85, PME-PLE 1.05. Width of anterior eye row 1.90, of second row 2.70, of third row 3.35. Clypeus height 0.33; chelicera length 4.00. Abdomen 9.20 long, 5.30 wide. Length of leg segments: I 9.80 + 4.20 + 9.10 (distal segments missing); II 9.70 + 3.80 + 9.00 + 11.70 + 5.00 (39.20); III 9.70 (distal segments missing); IV 11.40 + 4.20 (distal segments missing).

Colouration in alcohol (Figs 89-90): Specimen damaged and shabby. Carapace yellow brownish, densely covered with white setae. Sternum yellow, densely covered with white setae. Maxillae and labium yellow, with white tips. Chelicerae yellowish brownish, their frontal and lateral sides densely covered with white setae. Abdomen: dorsum densely covered with white setae, with a poorly marked cardiac mark; sides and venter densely covered with white setae. Book-lung covers yellow, densely covered with white setae. Spinnerets yellow brownish.

Figs 89-92. *Karakumosa repetek* sp. nov.; male paratype (89-90) and female paratype (91-92). (89, 92). Body, dorsal view. (90, 91) Ditto, ventral view. Scale bars 0.5 cm.

All legs yellow brownish, densely covered with white setae. Palp yellow, densely covered with white setae.
Palp structure (Figs 93-94, 97-102; mirrored image of right palp): Acutely pointed synembolic lamellae convergent to each other or bent proximad; median tooth bifurcated at its tip; proximal extension wide and long, spade-like; inner plate transverse and relatively narrow, with an extended, obtuse retrolateral-proximal shoulder; conductor triangular, pointed at its tip.

Female (paratype). *Measurements*: Carapace 9.20 long, 7.20 wide. Eye sizes and interdistances: AME 0.53, ALE 0.35, PME 1.03, PLE 1.05, AME-AME 0.28, AME-ALE 0.10, PME-PME 1.15, PME-PLE 1.15. Width of anterior eye row 2.10, of second row 2.80, of third row 3.35. Clypeus height 0.40; chelicera length 5.25. Abdomen 11.00 long, 7.30 wide. Length of leg segments: I-II absent; III 7.20 + 3.50 + 4.80 + 6.50 + 4.00 (26.00); IV absent.
Colouration in alcohol (Figs 91-92): Damaged specimen with only one legs remaining. Carapace brownish yellow, densely covered with white setae; its dorsal side with a brownish colour pattern consisting of two wide longitudinal paramedian bands. Sternum yellow, densely covered with white setae. Maxillae and labium yellow-brown, with yellow tips. Chelicerae brown, their frontal and lateral sides densely covered with white setae. Abdomen: dorsum densely covered with white setae, with a yellowish brown cardiac mark and a brownish colour pattern consisting of transverse stripes; sides and venter densely covered with white setae. Book-lung covers yellow, densely covered with white setae. Spinnerets yellow brownish. All legs brownish yellow, densely covered with white setae. Palps lost.
Epigyne and vulva (Figs 95-96): Epigynal atrium twice as long as wide, narrower at its proximal end and with slightly sigmoid lateral edges; posterior transverse plate dumbbell-shaped; spermathecae curved like a "C", bent mediad and tips directed anteriad.

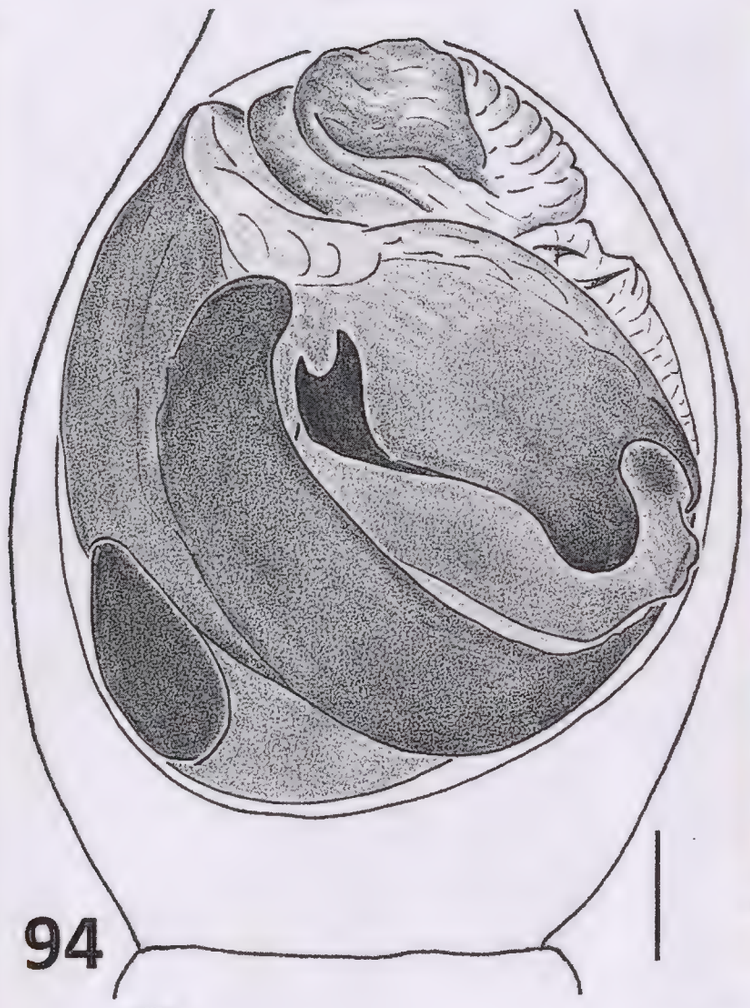
Distribution: Only known from the type locality, the Repetek Reserve in Turkmenistan (Fig. 76).

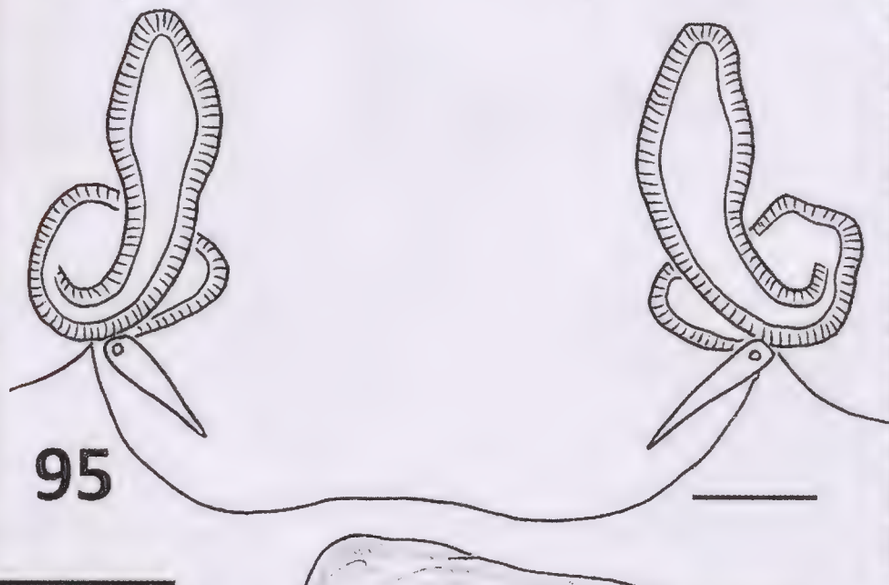
Karakumosa shmatkoi **sp. nov.**
Figs 103-141, 155

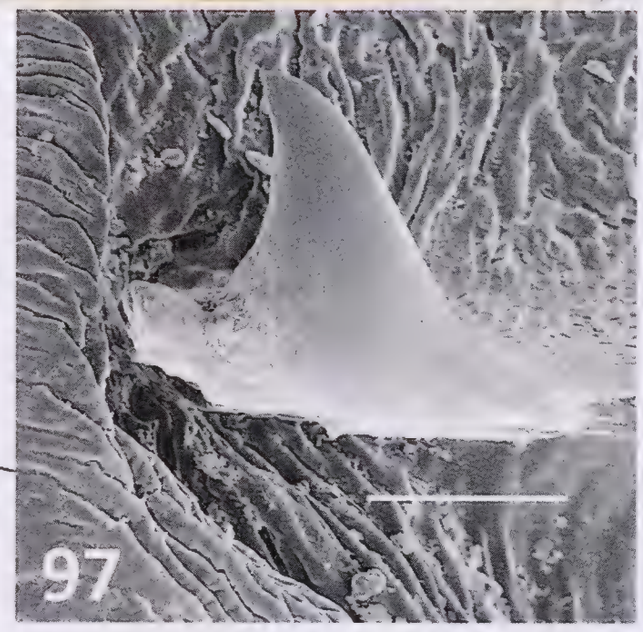
Lycosa alticeps (Kroneberg, 1875). – Schmidt, 1895: 450 (partim, misidentification). – Dunin, 1984: 55. – Minoransky & Ponomarev, 1984: 85-86 (all misidentifications).
"*Lycosa*" sp. 1. – Ponomarev & Abdurakhmanov, 2014: 92-93.
"*Lycosa*" sp. 2. – Ponomarev & Abdurakhmanov, 2014: 93.

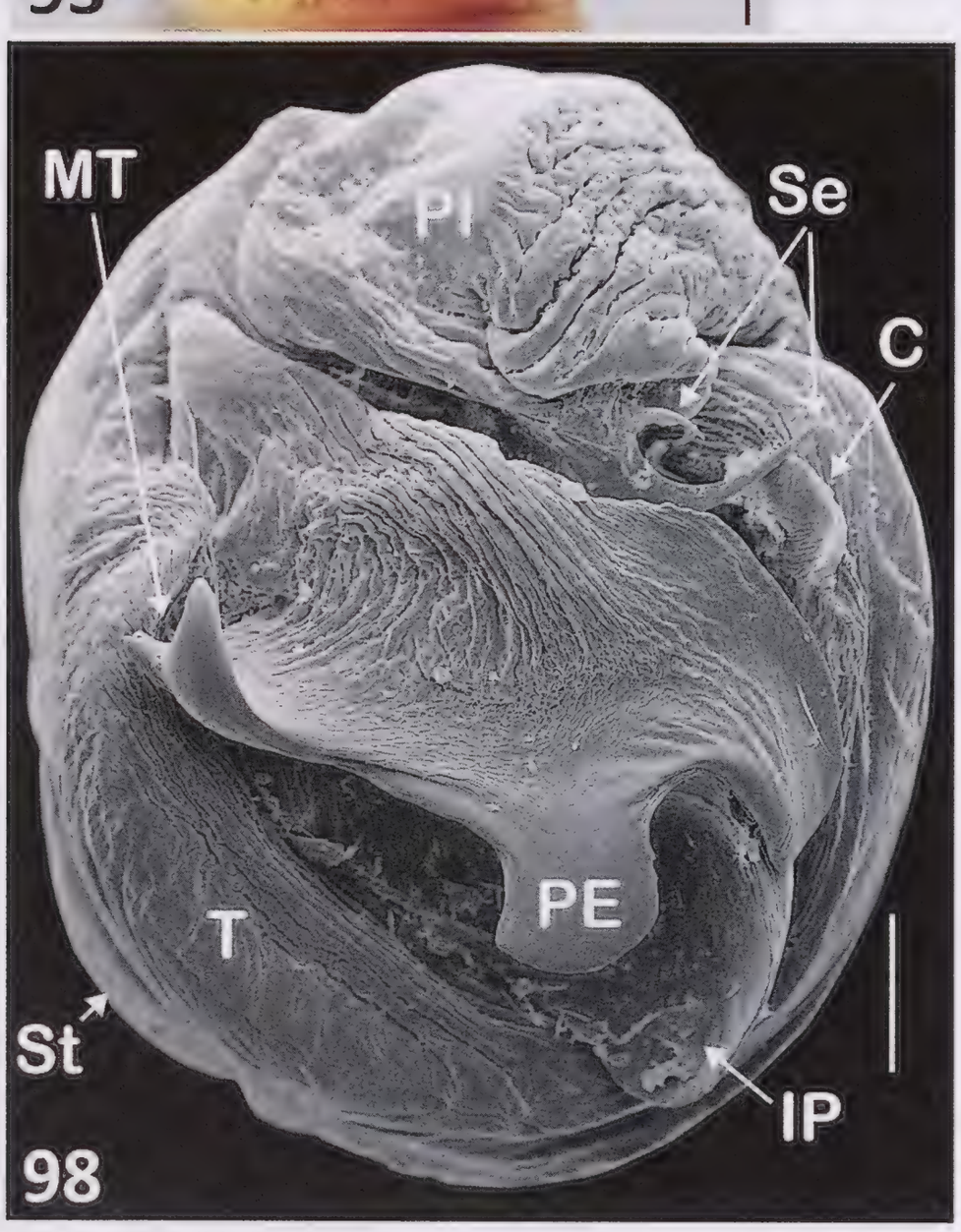
Holotype: ZMMU; male (Figs 105-106, 128, 132-133); KAZAKHSTAN, Atyrau Province, c. 20 km NE of Ganyushkino Vil., Zhuzguntyube stow (46°43'1.4"N, 49°25'32.1"E); 6.VII.1977; leg. F.A. Saraev.

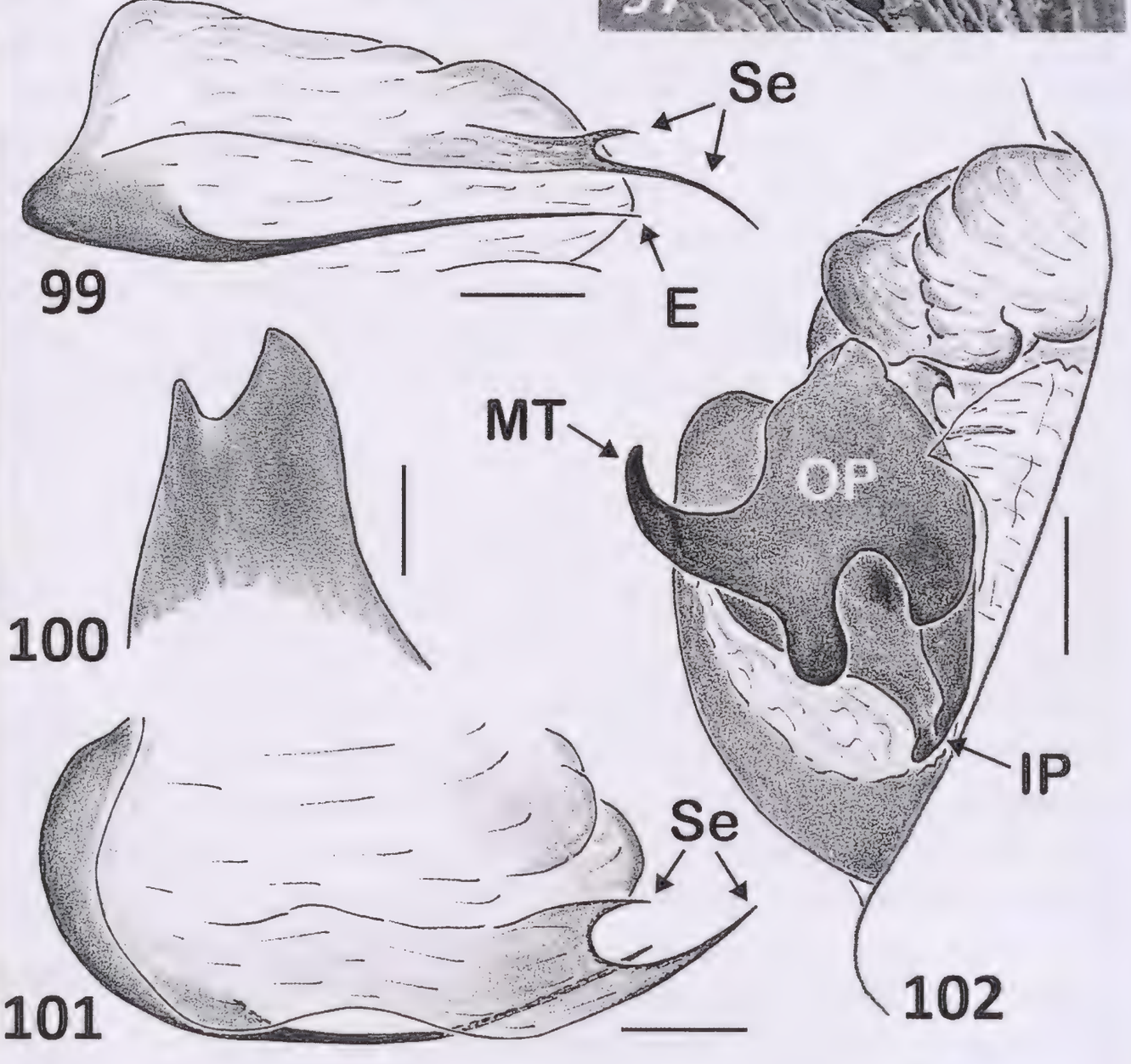
Paratypes: ZMMU; 1 female; same locality as for the holotype; 1.-10.VII.1977; leg. F.A. Saraev. – ISEA; 2 males; KAZAKHSTAN, Atyrau Province, Embinsk Distr., near Tengiz (46°23'49.9"N, 53°25'22.6"E); 8.VI.1986; leg. F.A. Saraev. – ZMMU; 1 male; KAZAKHSTAN, Atyrau Province, Embinsk Distr.,



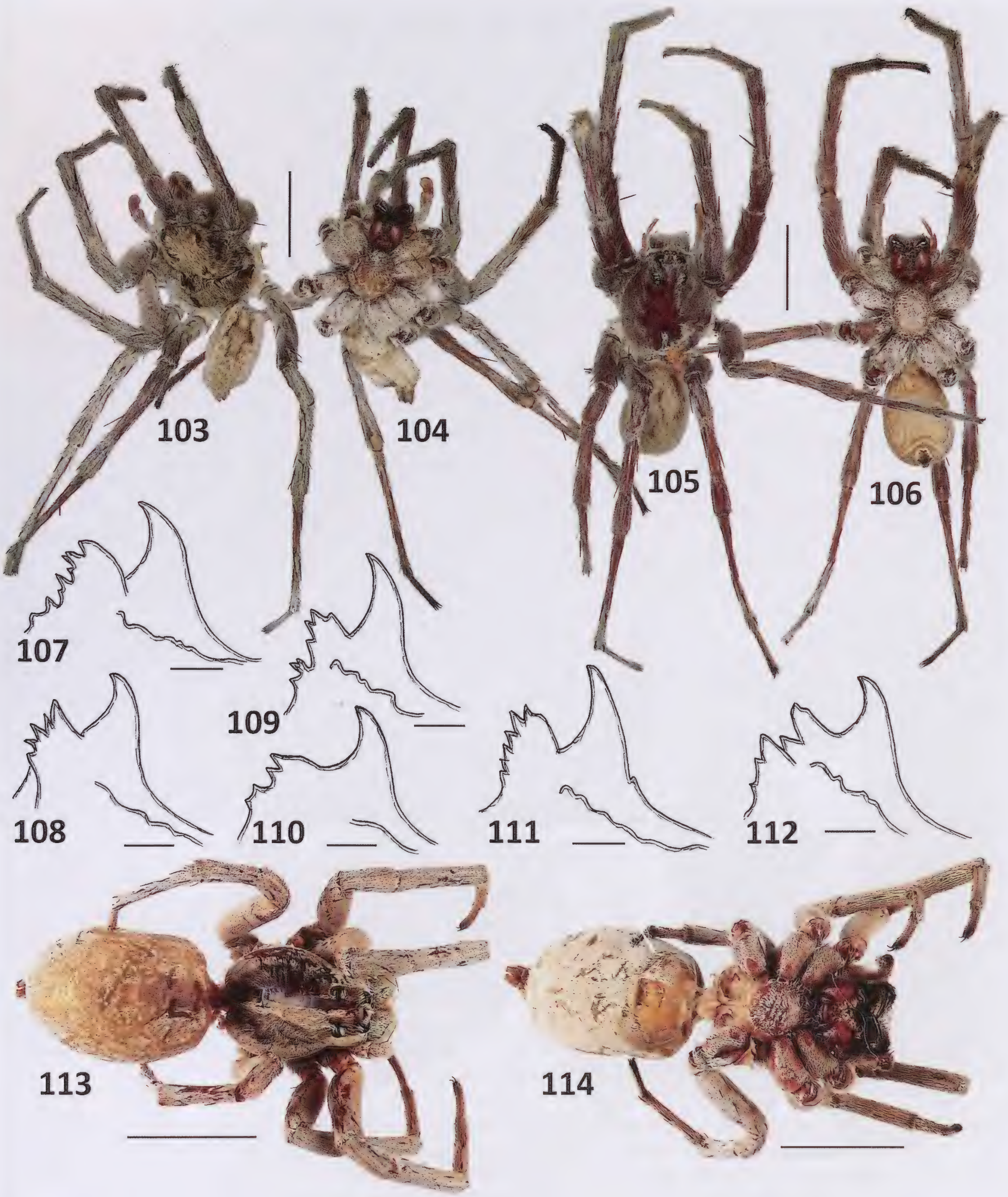




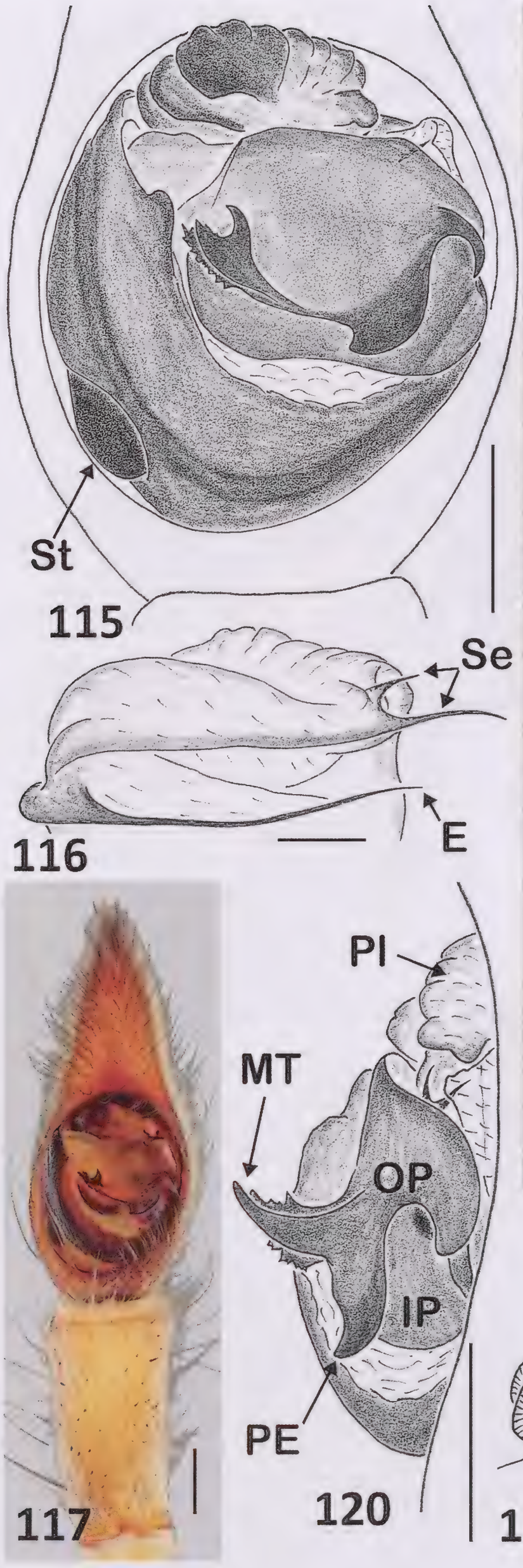


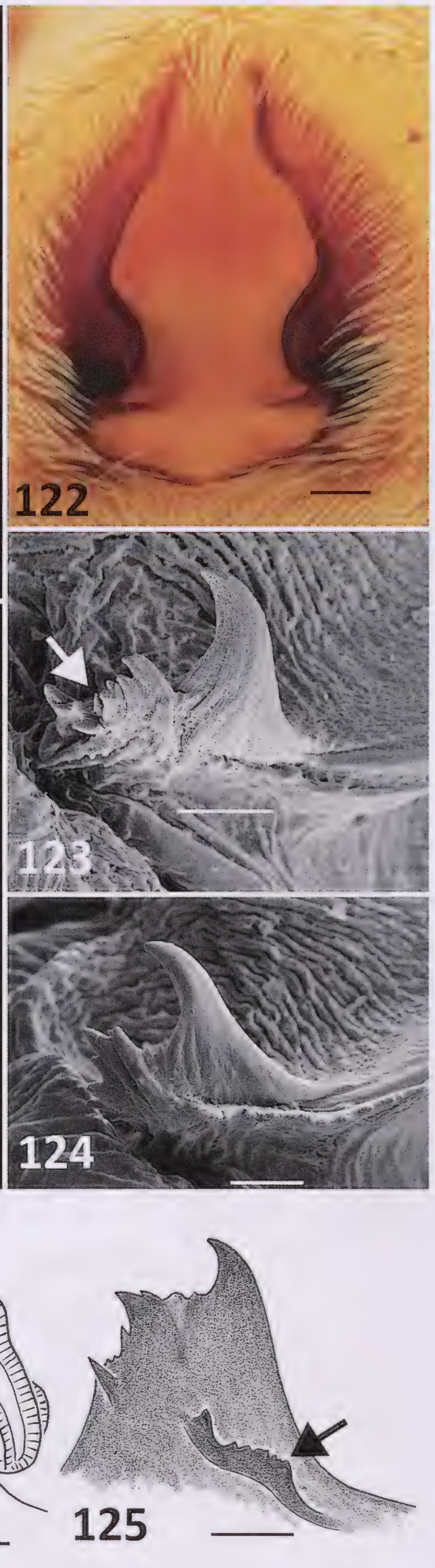


Figs 93-102. *Karakumosa repetek* sp. nov.; male holotype (97-98), male paratype (93-94, 99-102) and female paratype (95-96). (93-94, 98). Bulbus, ventral view. (95) Vulva, dorsal view. (96) Epigyne, ventral view. (97) Median tooth of MA, ventral view. (99) Embolic division, ventral view. (100) Median tooth of MA, posterior view. (101) Embolic division, apical view. (102) Bulbus, retrolateral view. Scale bars 0.5 mm (93, 96), 0.25 mm (94, 102), 0.2 mm (98), 0.1 mm (95, 97, 99-101). Abbreviations as explained in Material and methods.

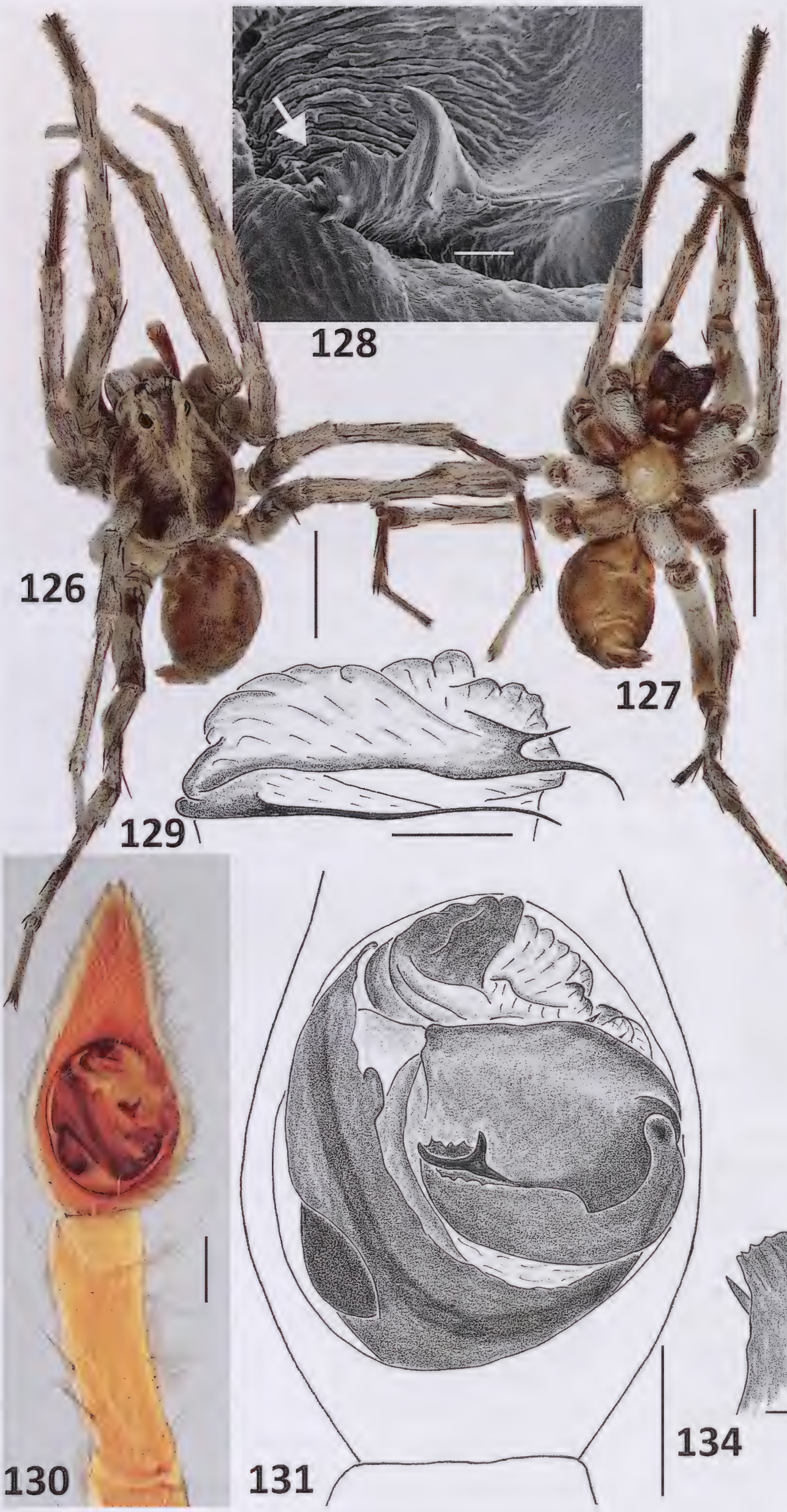


Figs 103-114. *Karakumosa shmatkoi* sp. nov.; male holotype (105-106), male paratype (103-104, 107-112) and female paratype (113-114); specimens from Kulaly Island (103-104, 109), Zhuzguntyube stow (105-106, 113-114), Mugodzhary Mts (107), Artezian Vil. (108, 110), Tengiz (111), Tyub-Karagan Peninsula (112). (103, 105, 113) Body, dorsal view. (104, 106, 114) Ditto, ventral view. (107-112) Median tooth of MA, posterior view. Scale bars 1 cm (103-106, 113-114), 0.1 mm (107-112).





Figs 115-125. *Karakumosa shmatkoi* sp. nov.; male paratypes (115-120, 123-125) and female paratype (121-122); specimens from Tyub-Karagan Peninsula (115-116, 118, 120, 123, 125), Island Kulaly (117), Zhuzguntyube stow (121-122) and Tengiz (119, 124). (115, 118-119) Bulbus, ventral view. (116) Embolic division. (117) Left male palp, ventral view. (120) Bulbus, retrolateral view. (121) Vulva, dorsal view. (122) Epigyne, ventral view. (123-125) Median tooth of MA, posterior view. Scale bars 0.25 mm (115, 117, 120, 122), 0.2 mm (118-119), 0.1 mm (116, 121, 123-125). Abbreviations as explained in Material and methods.



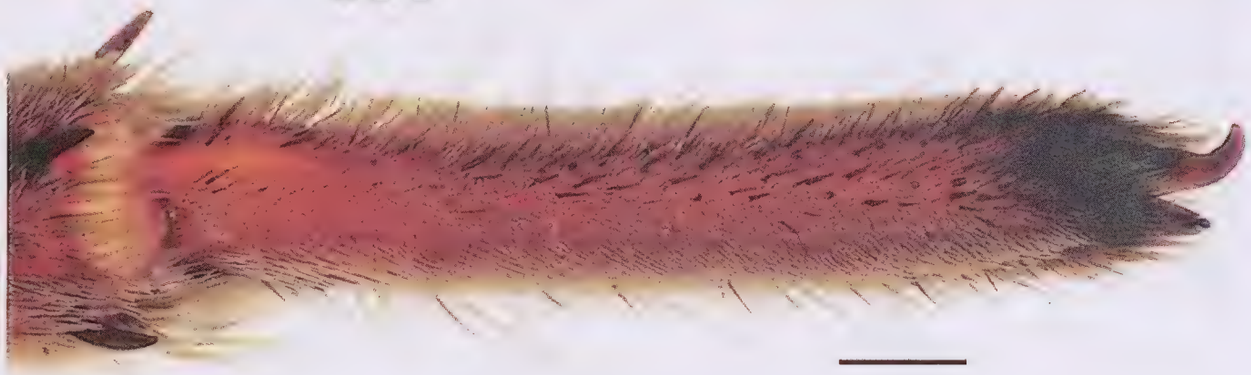
Figs 126-135. *Karakumosa shmatkoi* sp. nov.; male holotype (128, 132-133) and male paratype from Kalmykia, Utta Vil. (126-127, 129-131, 134-135). (126) Body, dorsal view. (127) Ditto, ventral view. (128, 134) Median tooth of MA, posterior view. (129) Embolic division. (130) Left male palp, ventral view. (131-132) Bulbus, ventral view. (133) Synembolus, apical view. (135) Bulbus, retrolateral view. Scale bars 1 cm (126-127), 0.5 mm (130-131, 135), 0.2 mm (132), 0.1 mm (128, 134).

136

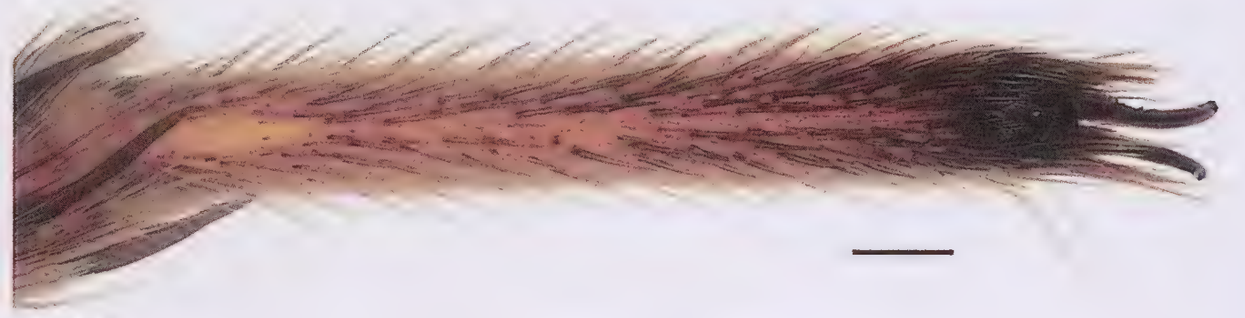
137

139

138



140



141

Figs 136-141. *Karakumosa shmatkoi* sp. nov., female from Azerbaijan, Absheron peninsula. (136) Prosoma, frontal view. (137) Ditto, ventral view. (138) Ditto, lateral view. (139) Epigyne, ventral view. (140) Tarsus I, ventral view. (141) Tarsus IV, ventral view. Scale bars 2 mm (137-138), 1 mm (136), 0.5 mm (140-141), 0.2 mm (139).

near Koschagyl (46°48'17.3"N, 53°43'50"E); 19.-24.VI.1987; leg. F.A. Saraev. – ZMMU; 6 males; KAZAKHSTAN, Mangistau Province, Mangyshlak, c. 10 km S of Fort Shevchenko, shore of Tyub-Karagan Peninsula (44°26'19.9"N, 50°15'19.9"E), hilly sands, pitfall traps; 17.VI.2013; leg. G.M. Abdurakhmanov. – ZMMU; 3 males; KAZAKHSTAN, Mangistau Province, Mangyshlak, Island Kulaly (44°53'31.4"N, 50°03'13.2"E), fine hilly sands, hand collecting; 19.VI.2013; leg. G.M. Abdurakhmanov. – MHNG; 2 males; same data. – PSU; 1 male; KAZAKHSTAN, Aktobe Province, c. 25 km ENE of Embi Vil., Mugodzhary Mts (c. 48°57'N, 58°39'E); 28.VI.2013; leg. A.O. Shkurikhin. – MMUE; 1 male; RUSSIA, Kalmykia, Yashkul Distr., c. 55 km NE of Yashkul Vil., near Utta Vil. (46°22'33.9"N, 46°01'18.5"E), hilly sands with sparse vegetation; 12.VI.1975; leg. A.V. Ponomarev. – ZMMU; 2 males; RUSSIA, Kalmykia, Chernozemel'sk Distr., c. 65 km SE of Komsomol'sky Vil., near Artezian Vil. (44°57'29.5"N, 46°37'53.5"E); 1.-4.VII.1976; leg. E.A. Khachikov.

Other material: ZMMU; 1 female (Figs 136-141); AZERBAIJAN, Absheron Peninsula (no exact locality); no date and collector given.

Etymology: The species is dedicated to our friend and colleague, Mr Vladimir Yu. Shmatko (Rostov-on-Don, Russia), who has been collaborating with the second author (AVP) in spider studies for many years and who took the majority of digital photos of *Karakumosa* species given in the present paper.

Diagnosis: The male of *K. shmatkoi* sp. nov. is most similar to those of *K. gromovi* sp. nov. (Figs 59, 60, 64-69) and *K. tashkumyr* sp. nov. (Figs 142-154); it can be distinguished from the former by the presence of a low serrate flange at the foot of the median tooth (absent in *K. gromovi* sp. nov.; Figs 125, 134 cf. Figs 74-75), and from the latter by a narrower inner plate of the median apophysis, which is almost hidden under the outer plate (Figs 118-119 cf. Figs 148, 150) and by the shape of the synembolus (Fig. 116 cf. Fig. 149). In the sigmoid lateral edges of the epigynal atrium, the female is similar to those of *K. repetek* sp. nov. (Figs 95-96) and *K. zyuzini* sp. nov. (Figs 179, 182), from which it differs in the shape of the posterior transverse plate (developed as a low, inverted triangle; Fig. 122 cf. Fig. 96 and Fig. 179) and by the spermathecae being visibly swollen (Fig. 121 cf. Fig. 95 and Fig. 182). See also comments above under 'Diagnosis' of *K. alticeps*.

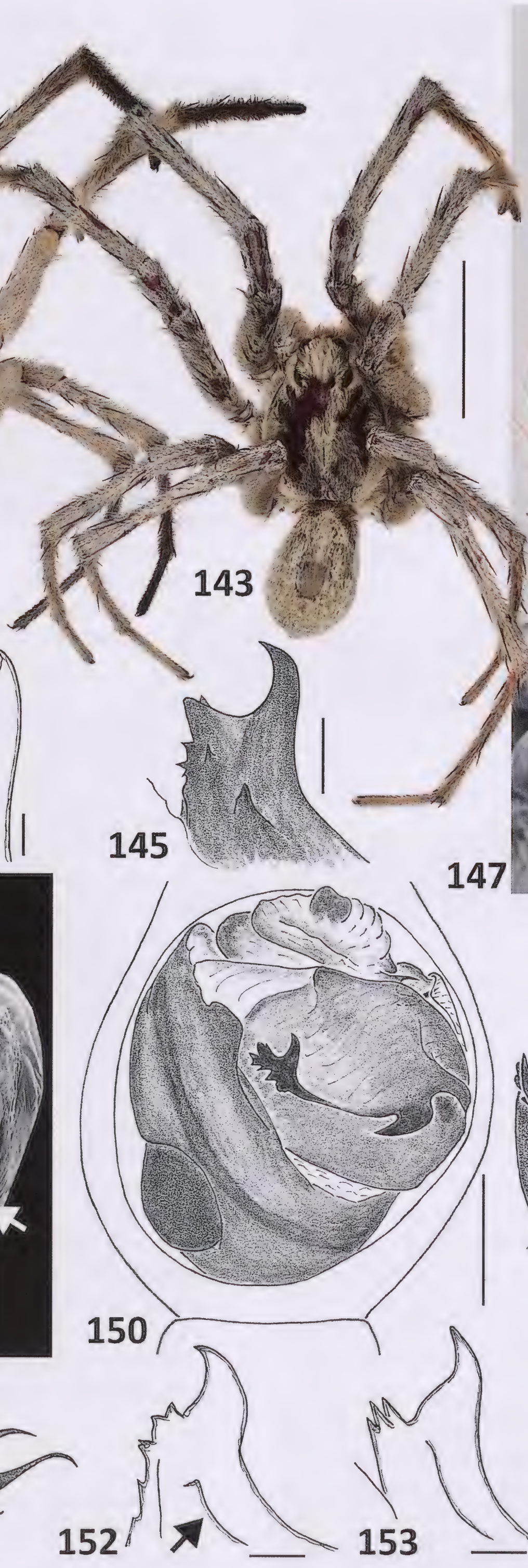
Description: Male (holotype). *Measurements*: Carapace 11.00 long, 9.30 wide. Eye sizes and interdistances: AME 0.45, ALE 0.40, PME 0.90, PLE 0.90, AME-AME 0.38, AME-ALE 0.15, PME-PME 1.20, PME-PLE 1.15. Width of anterior eye row 2.25, of second row 2.95, of third row 3.65. Clypeus height 0.35; chelicera length 4.00. Abdomen 10.50 long, 7.20 wide. Length of leg segments: I 10.00 + 5.00 + 9.80 + 10.00 + 4.80 (39.60); II 11.00 + 4.50 + 9.50 + 10.30 + 4.90 (40.20); III 10.00 + 3.80 + 7.60 + 9.80 + 4.20 (35.40); IV 12.00 + 4.10 + 9.70 + 13.50 + 5.40 (44.70). Leg formula: IV, II, I, III.
Colouration in alcohol (Figs 103-106, 126-127): Carapace dark brown, densely covered with yellowish white setae, without two wide brownish longitudinal paramedian bands. Sternum yellow-orange-coloured, densely covered with white setae. Maxillae and labium yellowish brown, with yellow tips. Chelicerae dark brown, their frontal and lateral sides densely covered with yellowish white setae. Abdomen: dorsum densely covered with white setae, with an indistinct cardiac mark outlined by brown lines; sides and venter yellow, densely covered with white setae. Book-lung covers yellow, densely covered with white setae. Spinnerets white. All legs yellow brownish, densely covered with white setae; metatarsi and tarsi of all legs ventrally darker (brown). Palp yellow, densely covered with white setae.
Palp structure (Figs 107-112, 115-120, 123-125, 128-135): Acutely pointed synembolic lamellae visibly convergent; median tooth developed as a large median claw with additional small teeth on its prolateral side and a prominent serrate ventral flange; proximal extension wide and hook-shaped; distance between proximal extension and median tooth wide, equal to two proximal extension widths; inner plate large, transverse-ovoid, its retrolateral shoulder extended and bent ventrad; conductor triangular, obtuse at its tip (pointed in other specimens).

Female (paratype). *Measurements*: Carapace 11.50 long, 8.60 wide. Eye sizes and interdistances: AME 0.45, ALE 0.35, PME 1.15, PLE 1.00, AME-AME 0.30, AME-ALE 0.18, PME-PME 1.20, PME-PLE 1.45. Width of anterior eye row 2.00, of second row 3.15, of third row 3.90. Clypeus height 0.50; chelicera length 4.85. Abdomen 14.00 long, 11.00 wide. Length of leg segments: I 9.80 + 4.10 + 7.00 + 6.20 + 3.50 (30.60); II 8.70 + 3.50 + 6.70 + 6.30 + 3.60 (28.80); III 8.00 + 3.60 + 5.80 + 6.80 + 3.60 (27.80); IV 10.00 + 4.50 + 7.00 + 9.50 + 3.90 (34.90). Leg formula: IV, I, II, III.
Colouration in alcohol (Figs 113, 114): Damaged and shabby specimen with abdomen detached from carapace. Carapace brown, densely covered with yellowish white setae and with two longitudinal lateral bands of brownish setae; carapace sides with wide marginal bands of white setae. Sternum brownish, densely covered with white setae. Maxillae and labium brown, with yellowish tips. Chelicerae dark brown, proximal half of frontal side densely covered with yellowish white setae. Abdomen: dorsum densely covered with yellowish white setae and with a large, wide, brownish cardiac mark; sides and venter, including book-lung covers, densely covered with white setae. Spinnerets brown. All legs and palps brownish yellow, densely covered with white setae. Palps with a claw at their tips.
Epigyne and vulva (Figs 121-122, 139): Epigynal atrium twice as long as wide, with markedly sigmoid lateral edges (almost S-shaped); posterior transverse plate developed as a low, inverted triangle, its central part slightly elevated and pointed backwards; spermathecae straight and visibly swollen in anterior portion, directed antero-mediad, inclined towards each other.

Comments: The males of *K. shmatkoi* sp. nov. examined display a noticeable variation in the shape of the proximal extension of the pedipalp which has either an obtuse (Fig. 132) or pointed (Figs 118-119) median shoulder. In the latter case, the proximal extension varies in its width, being visibly narrower (Fig. 118) or wider (Fig. 119). It is possible that more than one closely related species are here placed under the name of *K. shmatkoi* sp. nov. Unfortunately, the available material does not allow us to scrutinize the problem further; currently only one variety is known from both sexes. The problem needs special attention in the future when more material of both sexes from a larger number of localities is available.

Distribution: Known from two localities in Kalmykia, Russia (Minoransky & Ponomarev, 1984: sub *Lycosa alticeps*; present data), and from several localities in western Kazakhstan (Ponomarev & Abdurakhmanov 2014: sub "*Lycosa*" sp. 1 & "*Lycosa*" sp. 2; present data) and Azerbaijan (Absheron Peninsula, Baku and Chilov Island) (Schmidt, 1895; Dunin, 1984: sub *L. alticeps*; present data) (Fig. 155).

142


143

146

144

145

147

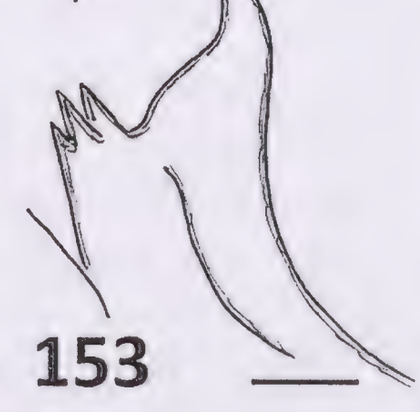
148

150

151

149

152


153

154

Figs 142-154. *Karakumosa tashkumyr* sp. nov., male paratypes, in ISEA. (142) Body, ventral view. (143) Ditto, dorsal view. (144) Left chelicera, ventral view. (145, 147, 152-154) Median tooth of MA, posterior view. (146) Left male palp, ventral view. (148, 150) Bulbus, ventral view. (151) Ditto, retrolateral view. (149) Embolic division. Scale bars 1 cm (142-143), 0.5 cm (144, 146, 150-151), 0.2 mm (148), 0.1 mm (145, 147, 149, 152-154).

Karakumosa tashkumyr sp. nov.

Figs 142-155

Holotype: ISEA, 001.8406; male; KYRGYZSTAN, Dzhalalabad Area, N of Taşkomur (=Tash-Kumyr) (c. 41°23'N, 72°14'E), clay hills; 14.-15.VI.1992; leg. A.A. Fedorov & A.A. Zyuzin.

Paratypes: ISEA; 7 males; collected together with the holotype. – ZMMU; 2 males; same data. – MMUE; 2 males; same data. – MHNG; 1 male; same data.

Etymology: The species epithet is a noun in apposition referring to the name of the type locality, Tash-Kumyr in Kyrgyzstan.

Diagnosis: In the presence of a low serrate flange at the foot of the median tooth of the MA, this species is most similar to *K. shmatkoi* sp. nov. (Figs 107-112, 115-120, 123-125, 128-135). The males of *K. tashkumyr* sp. nov. can be readily distinguished by the relative size of the inner plate of the MA, which in the ventral view is comparatively narrower and almost hidden beneath the outer plate in *K. shmatkoi* sp. nov. and wider and clearly visible in *K. tashkumyr* sp. nov. (Fig. 148 cf. Fig. 118 and Fig. 119), and by the shape of the synembolus: both tips of the lamellae markedly bent downwards in *K. tashkumyr* sp. nov. *vs.* upper tip straight in *K. shmatkoi* sp. nov. (Fig. 149 cf. Fig. 116 and Fig. 129). The female of *K. tashkumyr* sp. nov. is unknown.

Description: Male (paratype, ISEA). *Measurements*: Carapace 12.00 long, 8.60 wide. Eye sizes and interdistances: AME 0.55, ALE 0.40, PME 1.10, PLE 1.20, AME-AME 0.30, AME-ALE 0.20, PME-PME 1.00, PME-PLE 1.50. Width of anterior eye row 2.55, of second row 3.35, of third row 4.00. Clypeus height 0.43; chelicera length 5.50. Abdomen 10.50 long, 6.80 wide. Length of leg segments: I 11.50 + 5.10 + 11.00 + 12.40 + 5.20 (45.20); II 11.50 + 4.80 + 10.20 + 12.40 + 5.40 (44.30); III 11.00 + 4.40 + 8.80 + 12.50 + 5.50 (42.20); IV 13.00 + 4.70 + 10.10 + 15.40 + 6.00 (49.20). Leg formula: IV, I, II, III.

Colouration in alcohol (Figs 142-143): Carapace brown, densely covered with yellowish white setae and with two wide brownish longitudinal bands. Sternum yellow-orange-coloured, densely covered with white setae. Maxillae half brownish and half yellow-orange-coloured. Labium brownish yellow, with a yellow tip. Chelicerae dark brown, their frontal and lateral sides densely covered with white setae. Abdomen: dorsum densely covered with white setae, with an indistinct brownish cardiac mark; sides and venter yellow, densely covered with white setae. Book-lung covers yellow, densely covered with white setae. Spinnerets yellow brownish. All legs yellow brownish, densely covered with white setae; metatarsi and tarsi of all legs ventrally darker (brownish). Palps yellow-orange-coloured, densely covered with white setae.

Palp structure (Figs 145-154): Acutely pointed synembolic lamellae bent downwards; median tooth developed as a large median claw with additional small teeth on its prolateral side and a prominent ventral flange looking like an additional tooth; proximal extension wide and hook-shaped; distance between proximal extension and median tooth wide, equal to two proximal extension widths; inner plate large, transverse-ovoid, its retrolateral shoulder bent ventrad; conductor triangular, obtuse at its tip.

Female. Unknown.

Distribution: Only known from the type locality, north of Taşkomur in Dzhalalabad Area of Kyrgyzstan (Fig. 155).

Karakumosa turanica sp. nov.

Figs 155-168

Tarentula alticeps Kroneberg, 1875: 40, pl. 4, fig. 28 (*partim*; misidentification of paralectotypes from Uzbekistan).

Lycosa alticeps (Kroneberg, 1875). – Simon, 1899: 479. – Vlassov & Sytshevskaja, 1937: 250. – Mikhialov & Fet, 1994: 508 (misidentification of specimens from Ashgabat).

Holotype: ZISP; 1 male; TURKMENISTAN, [Balkan Velayat], between Serdar (=Kyzyl-Arvat) and Iskander (c. 39°03'N, 56°07'E); 6.VI.1936; leg. S. Nenyukov.

Paratypes: ZISP; 2 females; "ex vil. Melnikova" near Ashgabad (c. 37°59'N, 58°20'E); summer and autumn, 1933; collector unknown.

Other material: ZMMU, Ta-1215; 1 female (paralectotype of *Tarentula alticeps*; Figs 165, 168); [UZBEKISTAN], "Ulus" [c. 39°34'N, 66°22'E]; no date; [A.P.] Fedchenko (Turkestan scientific expedition of the Imperial Society of Devotees of Natural Science). – ZMMU, Ta-1216; 1 subadult male, 3 immature females (paralectotypes of *Tarentula alticeps*); [UZBEKISTAN], Samarkand [c. 39°37'N, 66°57'E]; no date; leg. [A.P.] Fedchenko (Turkestan scientific expedition of the Imperial Society of Devotees of Natural Science).

Etymology: The specific epithet is latinized adjective derived from the name 'Turan', a historic region of Central Asia.

Diagnosis: The male of *K. turanica* sp. nov. is most similar to that of *K. alticeps*, but can be easily distinguished by a markedly pointed and wider median shoulder of the proximal extension (narrower and obtuse in *K. alticeps*; Fig. 161 cf. Fig. 2 and Fig. 12) and by the larger, quadrangular median tooth (smaller, triangular median tooth with a serrate prolateral edge in *K. alticeps*; Fig. 164 cf. Figs 5-8). The female of *K. turanica* sp. nov. is most similar to that of *K. zyuzini* sp. nov., from which it can be distinguished by an

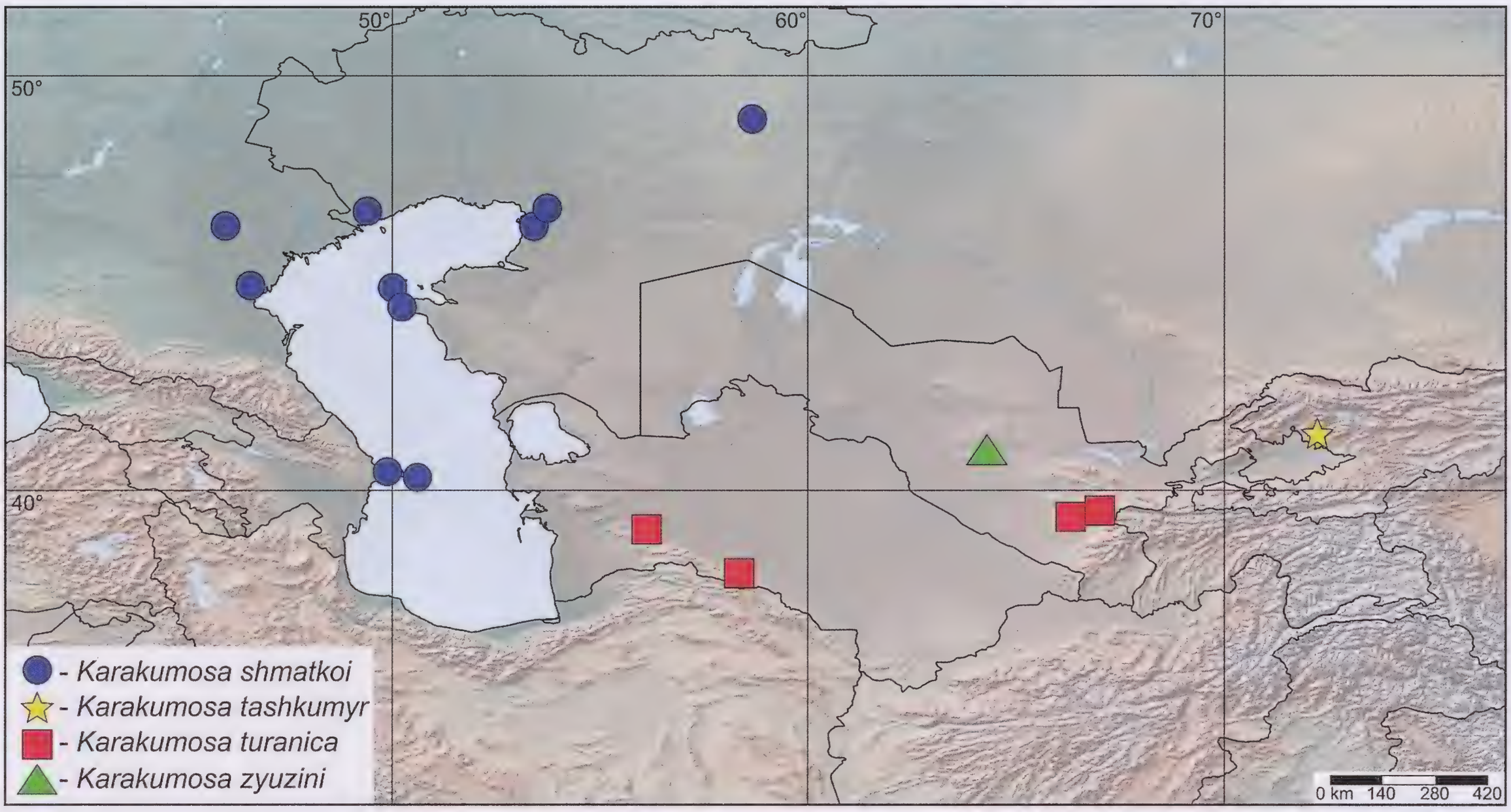
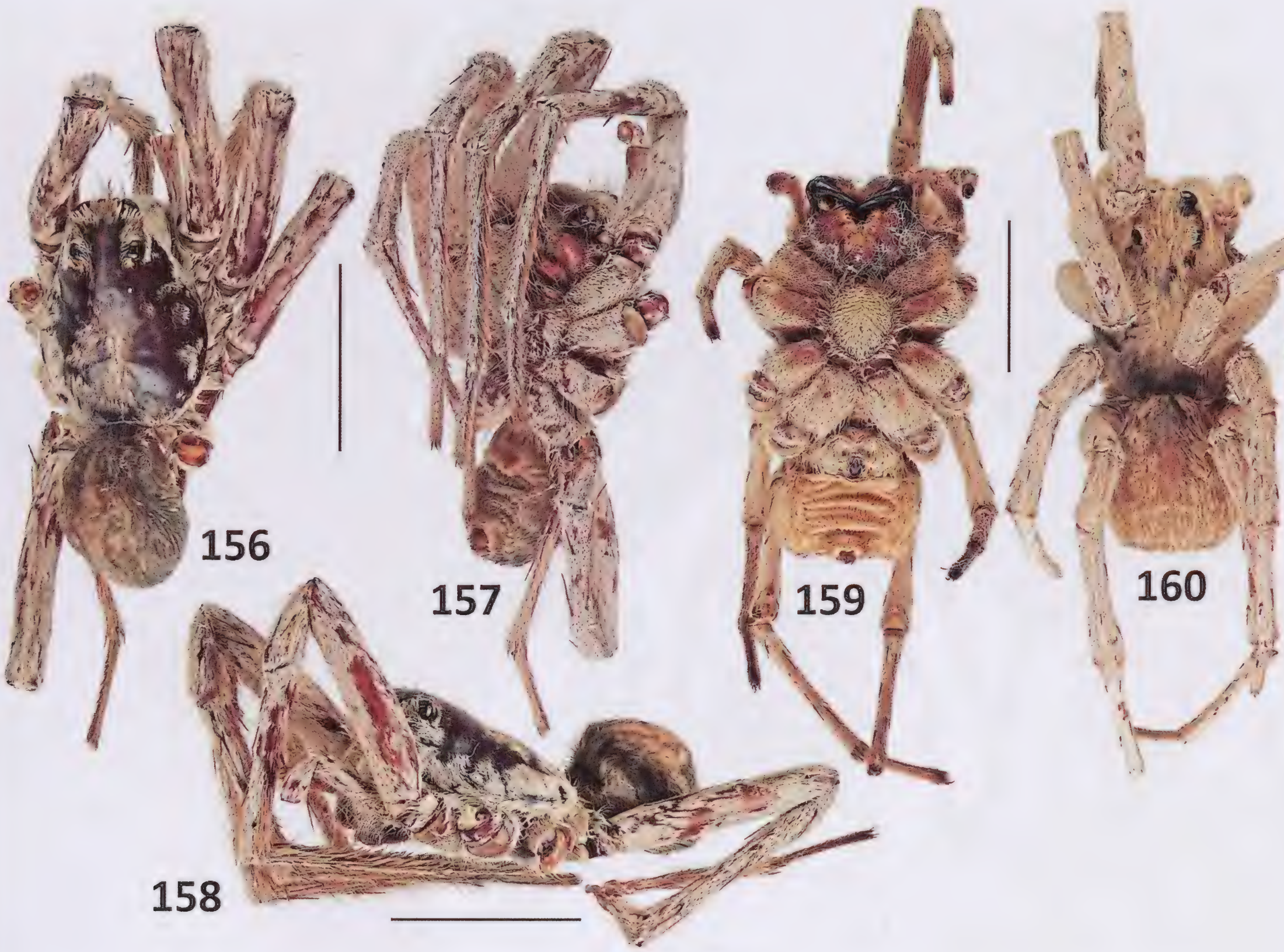


Fig. 155. Localities of four species in the genus *Karakumosa* gen. nov.

anchor-shaped posterior transverse plate (parallel-sided in *K. zyuzini* sp. nov.; Figs 167-168 cf. Fig. 179) and by spermathecae directed anteriad (inclined antero-mediad in *K. zyuzini* sp. nov.; Figs 165-166 cf. Fig. 182).

Description: Male (holotype). *Measurements*: Carapace 10.70 long, 8.50 wide. Eye sizes and interdistances: AME 0.45, ALE 0.45, PME 1.20, PLE 1.15, AME-AME 0.35, AME-ALE 0.15, PME-PME 1.00, PME-PLE 2.15. Width of anterior eye row 2.35, of second row 3.15, of third row 3.80. Clypeus height 0.45; chelicera length 4.70. Abdomen 8.80 long, 5.80 wide. Length of leg segments: I 11.10 + 4.00 + 9.40 + 11.50 + 4.60 (40.60); II 10.80 + 4.40 + 8.50 + 10.50 + 4.60 (38.80); III 11.10 + 3.80 + 7.50 + 11.10 + 4.30 (37.80); IV 12.10 + 3.80 + 9.10 + 12.60 + 5.50 (43.10). Leg formula: IV, I, II, III.
Colouration in alcohol (Figs 156-158): Specimen in poor condition, damaged, shabby, with some legs and left palp missing. Carapace dark brown, densely covered with yellowish white setae; colour pattern of longitudinal brown stripes indiscernible due to poor condition. Sternum brown, densely covered with yellowish white setae. Maxillae and labium yellowish brown. Chelicerae dark brown, their frontal and lateral sides densely covered with yellowish white setae. Abdomen: dorsum densely covered with grey yellowish setae, with a poorly marked brownish cardiac mark; the frontal part of abdomen brownish; sides and venter, including book-lung covers, brownish, densely covered with yellowish white setae. Spinnerets yellow light brown. All legs light brown, densely covered with yellowish white setae. Palps yellow-orange-coloured, densely covered with yellowish white setae.
Palp structure (Figs 161-164; mirrored image of right palp): Acutely pointed synembolic lamellae markedly convergent towards each other; median tooth large and wide; proximal extension wide and pointed at its median angle, distance between proximal extension and median tooth narrow, equal to or less than a proximal extension width; inner plate rather narrow, almost hidden beneath outer plate; conductor triangular, pointed at its tip.

Female (paratype). *Measurements*: Carapace 12.60 long, 9.60 wide. Eye sizes and interdistances: AME 0.55, ALE 0.60, PME 1.25, PLE 0.65, AME-AME 0.30, AME-ALE 0.15, PME-PME 1.40, PME-PLE 2.60. Width of anterior eye row 2.90, of second row 3.60, of third row 4.35. Clypeus height 0.45; chelicera length 6.60. Abdomen 10.00 long, 8.60 wide. Length of leg segments: I 10.00 + 4.60 + 8.00 + 7.50 + 4.00 (34.10); II 9.50 + 4.40 + 6.90 + 7.60 + 4.00 (32.40); III 8.50 + 3.90 + 6.30 + 7.70 + 3.80 (30.20); IV 10.80 + 4.50 + 8.30 + 11.00 + 4.70 (39.30). Leg formula: IV, I, II, III.
Colouration in alcohol (Figs 159-160): Carapace brown, densely covered with yellowish white setae, without two longitudinal paramedian bands of brownish setae; carapace margins with wide bands of yellowish white setae. Sternum brown, densely covered with yellowish white setae. Maxillae and labium brown, with yellowish tips. Chelicerae dark brown, proximal part of frontal side densely covered with yellowish white setae. Abdomen: dorsum brownish, densely covered with yellowish white



Figs 156-160. *Karakumosa turanica* sp. nov., male holotype (156-158) and female paratype (159-160). (156, 160) Body, dorsal view. (157, 159) Ditto, ventral view. (158) Ditto, lateral view. Scale bars 1 cm.

setae, with a poorly marked brownish cardiac mark; sides and venter, including book-lung covers, densely covered with yellowish white setae. Spinnerets brown. All legs and palps brownish yellow, densely covered with white setae; tips of all leg tarsi darker (brown). Palps with a claw at their tips.

Epigyne and vulva (Figs 165-168): Epigynal atrium twice as long as wide, with slightly sigmoid lateral edges; posterior transverse plate narrow, anchor-shaped, its posterior margin widely procurved; spermathecae tube-shaped and straight, directed anteriad.

Comments: Male and female specimens of *K. turanica* sp. nov. were not collected together and hence are matched provisionally, on the ground that (1) both sexes were collected from lowland sites of Turkmenistan lying relatively close to each other (Fig. 155), and (2) two other *Karakumosa* species known from the plains of Turkmenistan (*K. badkhyzica* sp. nov. and *K. repetek* sp. nov.; Fig. 76) are described from both sexes collected together; these are distinct from *K. turanica* sp. nov.

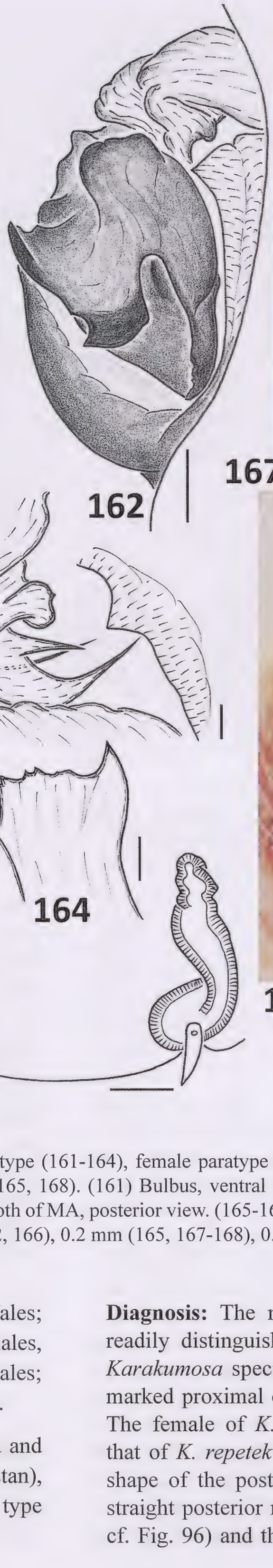
The female paralectotype of *K. alticeps* (Figs 165, 168) turned out to be conspecific with female paratypes of *K. turanica* sp. nov. (Figs 166-167), and therefore its record from Samarkand is included in the account of *K. turanica* sp. nov. See also 'Comments' above under *K. alticeps*.

Distribution: Known from a few localities in Turkmenistan and Uzbekistan (Fig. 155), but it is believed that the species is more widespread across the plains of Central Asia, within the so-called Turan zoogeographic province (*sensu* Kryzhanovsky, 2002). Besides, some of the old records of *Lycosa alticeps* from Turkmenistan by Schmidt (1895) could also belong to this species: viz., the records from Uch-Adzhi (c. 38°05'N, 62°48'E) and Turkmenbashi (c. 40°02'N, 52°59'E).

Karakumosa zyuzini sp. nov.

Figs 155, 169-186

Holotype: ISEA, 001.8405; male; UZBEKISTAN, Navoiy Region, Kanimekh Distr., near Chengeldy (c. 40°56'44.1"N, 64°18'06.0"E), flat clay clough between sandy plots; 22.-23.V.1994; leg. A.A. Zyuzin.



Figs 161-168. *Karakumosa turanica* sp. nov., male holotype (161-164), female paratype (166-167) and paralectotype of *Tarentula alticeps* newly identified as *K. turanica* (165, 168). (161) Bulbus, ventral view. (162) Ditto, retrolateral view. (163) Synembolus, apical view. (164) Median tooth of MA, posterior view. (165-166) Vulva, dorsal view. (167-168) Epigyne, ventral view. Scale bars 0.25 mm (161-162, 166), 0.2 mm (165, 167-168), 0.1 mm (163-164).

Paratypes: ISEA, 001.4188; 11 males, 3 females; collected together with the holotype. – ZMMU; 2 males, 2 females; same data. – MMUE; 3 males, 3 females; same data. – MHNG; 2 males, 2 females; same data.

Etymology: The species is dedicated to our friend and colleague, Dr Alexei A. Zyuzin (Almaty, Kazakhstan), an expert on the Lycosidae, who collected the type specimens of this species.

Diagnosis: The male of *K. zyuzini* sp. nov. can be readily distinguished from males of all other known *Karakumosa* species by the shape of the large, poorly marked proximal extension of the MA (Figs 174, 176). The female of *K. zyuzini* sp. nov. is most similar to that of *K. repetek* sp. nov. from which it differs in the shape of the posterior transverse epigynal plate (with straight posterior margin *vs.* dumbbell-shaped, Fig. 179 cf. Fig. 96) and the straight *vs.* C-curved spermathecae

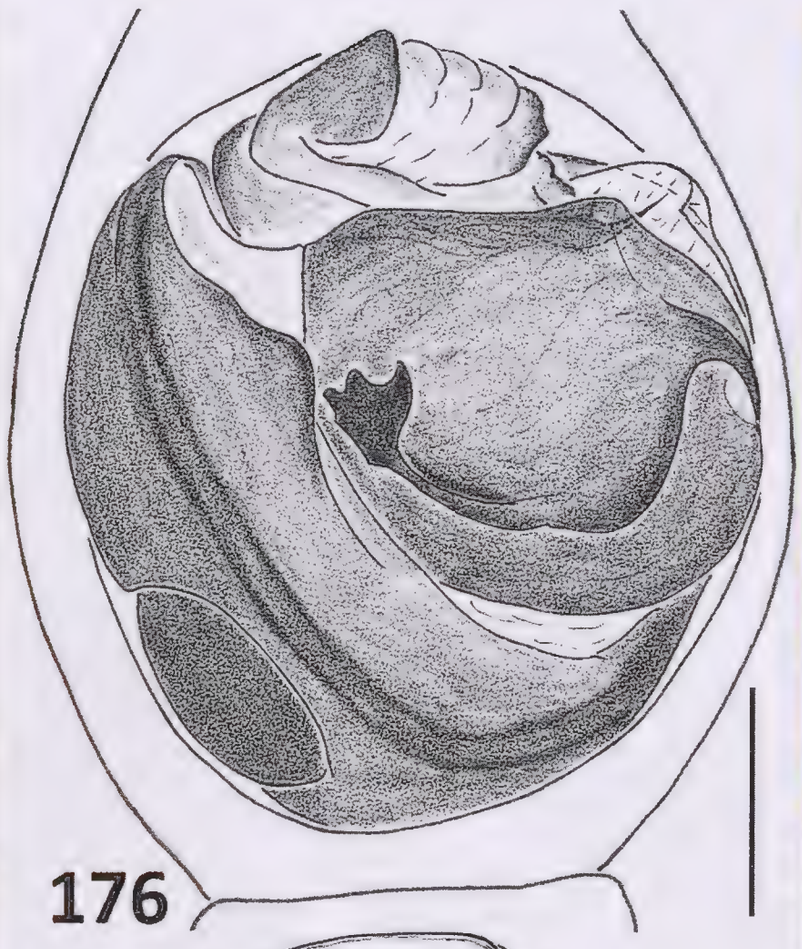
Figs 169-172. *Karakumosa zyuzini* sp. nov., male paratype (169-170) and female paratype (171-172), in MMUE. (169, 171) Body, ventral view. (170, 172) Ditto, dorsal view. Scal bars 1 cm.

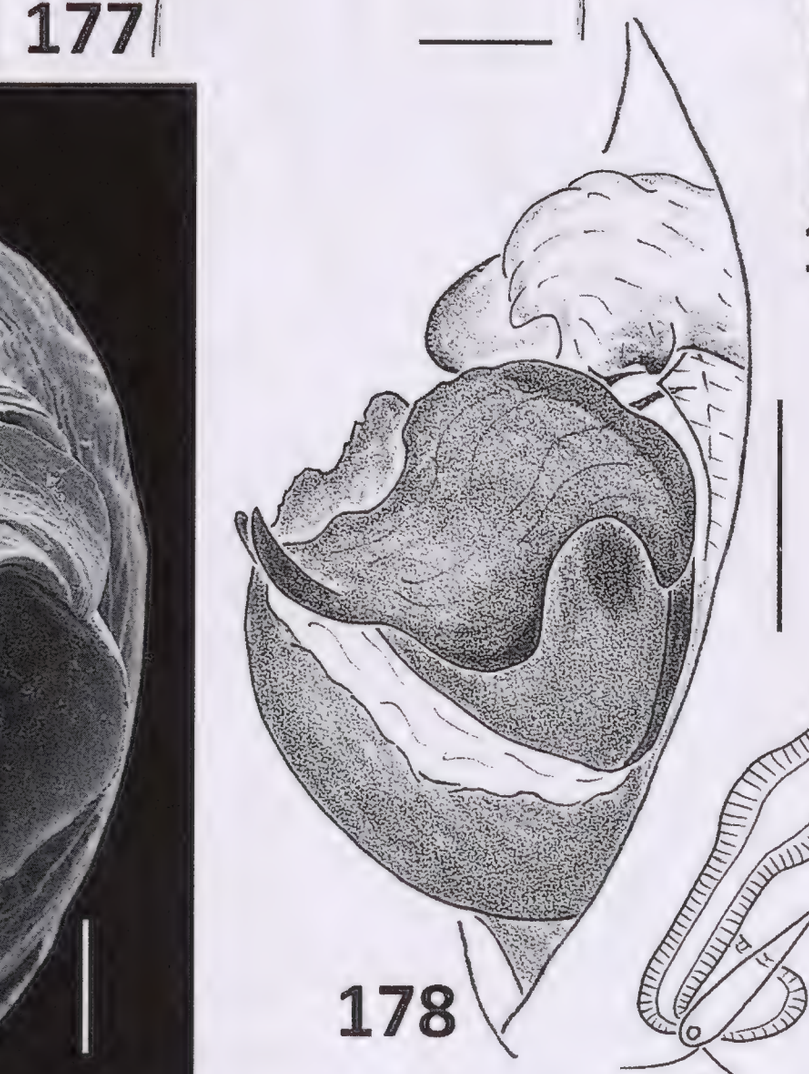
(Fig. 182 cf. Fig. 95). See also comments under 'Diagnoses' of *K. shmatkoi* sp. nov. and *K. turanica* sp. nov.

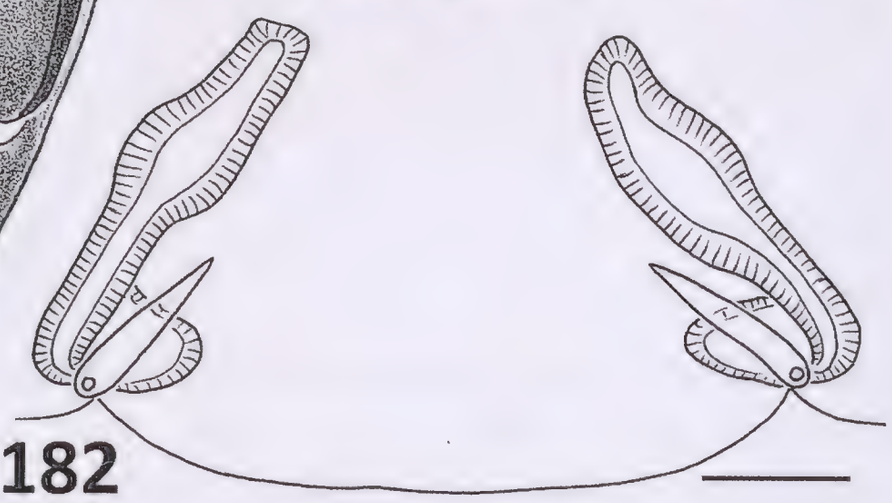
Description: Male (paratype, MMUE). *Measurements*: Carapace 10.50 long, 8.00 wide. Eye sizes and interdistances: AME 0.51, ALE 0.35, PME 1.00, PLE 0.90, AME-AME 0.25, AME-ALE 0.30, PME-PME 1.25, PME-PLE 1.40. Width of anterior eye row 2.00, of second row 3.00, of third row 3.90. Clypeus height 0.37; chelicera length 4.30. Abdomen 10.50 long, 6.30 wide. Length of leg segments: I 11.00 + 4.00 + 9.90 + 9.80 + 5.00 (39.70); II 10.50 + 3.80 + 9.10 + 10.00 + 4.80 (38.20); III 9.30 + 3.30 + 7.10 + 10.50 + 4.10 (34.30); IV 11.50 + 3.80 + 9.60 + 13.80 + 5.00 (43.70). Leg formula: IV, I, II, III.

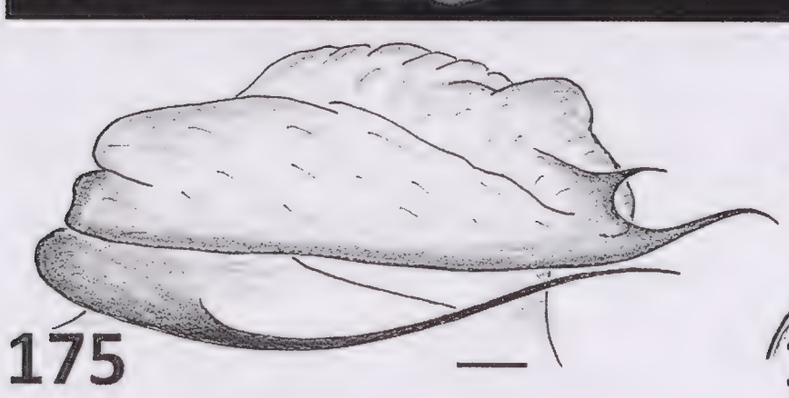
Colouration in alcohol (Figs 169-170): Carapace brown, densely covered with white setae and with two poorly-marked wide brownish longitudinal paramedian bands. Sternum yellow, densely covered with white setae. Maxillae brownish yellow. Labium brownish yellow, with yellow tip. Chelicerae brown, their frontal and lateral sides densely covered with white setae. Abdomen: dorsum densely covered with white setae, with a brownish colour pattern consisting of longitudinal lines outlining cardiac mark and transverse lines in rear half of dorsum; sides and venter yellow, densely covered with white setae. Book-lung covers yellow, densely covered with white setae. Spinnerets yellow brownish. All legs yellow brownish, densely covered with white setae; metatarsi and tarsi of all legs ventrally darker (brownish). Palp yellow brownish, densely covered with white setae. *Palp structure* (Figs 173-178, 180-181, 183-186): Acutely pointed synembolic lamellae both curved downwards and subparallel to each other; median tooth bifurcated, with a serrated prolateral edge; proximal extension large and ovoid, not distinct from margin of outer plate; inner plate large, transverse-ovoid; conductor triangular, pointed at its tip.

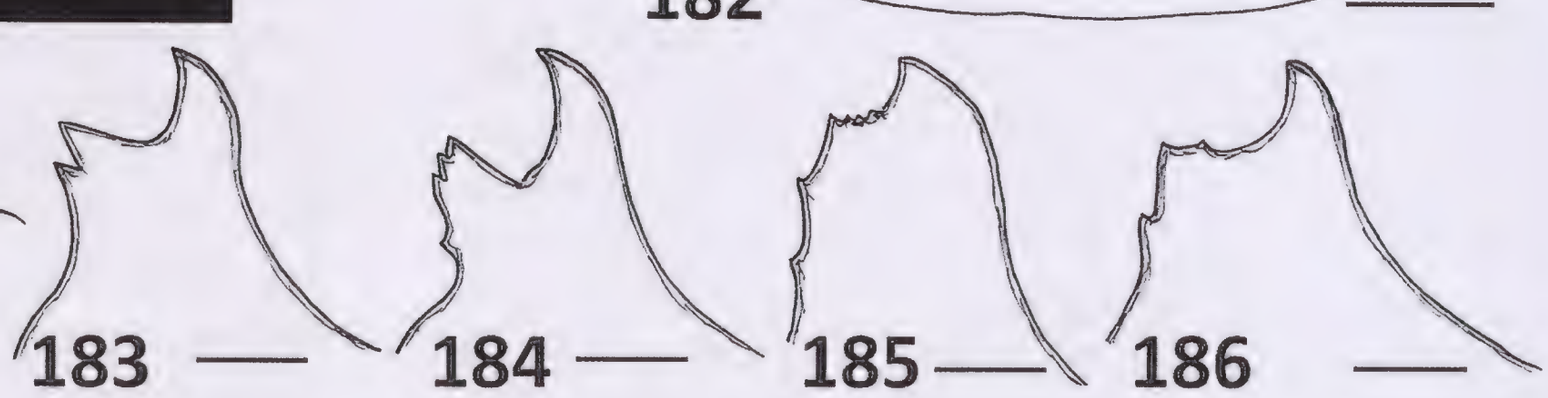
Female (paratype, MMUE). *Measurements*: Carapace 12.00 long, 9.70 wide. Eye sizes and interdistances:











Figs 173-186. *Karakumosa zyuzini* sp. nov., male paratype (173-176, 178, 180-181, 183-186) and female paratype (177, 179, 182), in MMUE. (173-174, 176) Bulbus, ventral view. (175) Embolic division. (177) Left female chelicera, ventral view. (178) Bulbus, retrolateral view. (179) Epigyne, ventral view. (180-181, 183-186) Median tooth of MA, posterior view. (182) Vulva, dorsal view. Scale bars 0.5 mm (173, 176-179), 0.25 mm (182), 0.2 (174), 0.1 mm (175, 180-181, 183-186).

AME 0.50, ALE 0.40, PME 1.00, PLE 1.00, AME-AME 0.40, AME-ALE 0.25, PME-PME 1.40, PME-PLE 1.60. Width of anterior eye row 2.40, of second row 3.00, of third row 4.25. Clypeus height 0.65; chelicera length 6.20. Abdomen 16.20 long, 12.00 wide. Length of leg segments: I 10.00 + 4.20 + 8.10 + 6.50 + 3.70 (32.50); II 9.40 + 4.10 + 7.40 + 7.10 + 3.60 (31.60); III 8.50 + 3.90 + 6.10 + 7.50 + 3.90 (29.90); IV 11.00 + 4.00 + 8.60 + 10.50 + 4.60 (38.70). Leg formula: IV, I, II, III.

Colouration in alcohol (Figs 171-172): Carapace dark brown, densely covered with yellowish white setae and with a poorly marked pattern of two wide brownish longitudinal paramedian bands. Sternum yellow-orange-coloured, densely covered with white setae. Maxillae and labium brown, with yellow tips. Chelicerae dark brown, their frontal and lateral sides densely covered with yellowish white setae. Abdomen: dorsum densely covered with yellowish white setae, with a brownish cardiac mark; sides and venter yellow, densely covered with white setae. Book-lung covers yellow, covered with white setae. Spinnerets yellow brownish. All legs yellow brownish, densely covered with white setae; metatarsi and tarsi of all legs darker (brownish). Palp yellow brownish, densely covered with white setae, carrying a tarsal claw.

Epigyne and vulva (Figs 179, 182): Epigynal atrium twice as long as wide, with almost subparallel, slightly sigmoid lateral edges; posterior transverse plate narrow and straight; spermathecae tube-shaped, slightly swollen in anterior part and straight, directed antero-mediad, inclined towards each other.

Distribution: Only known from the type locality, Chengeldy in Navoiy Region of Uzbekistan (Fig. 155).

DISCUSSION

Karakumosa gen. nov. is part of a rather diverse and poorly studied fauna of the burrying wolf spiders of Central Asia. To date 30 species in nine genera of fossorial Lycosidae have been recorded/described from Central Asia (Table 1), but their regional diversity is likely to be much higher. The only comparable regional Palaeartic fauna of fossorial lycosids is that of Europe, including the Mediterranean, from where 32 species in five genera are currently known (Nentwig *et al.*, 2020). The striking difference between the Central Asian and European faunas is the diversity of *Lycosa* Sundevall, 1833 accounting for 25 species in Europe and only three in Central Asia. At least 12 west-Mediterranean species of the *tarantula*-group of *Lycosa* have been recently revised (Planas *et al.*, 2013) and thus the observed regional differences in *Lycosa* diversity are not accidental. Each region has a unique, monotypic genus of fossorial lycosids: *Donacosa* Alderweireldt & Jocqué, 1991 known only from south-western Spain (see Alderweireldt & Jocqué, 1991) and *Oculicosa* confined to the Ustyurt Plateau and the Kyzylkum Desert (see Logunov & Gromov, 2011).

Currently only three species of fossorial lycosids occur between Europe and Central Asia (Marusik *et al.*, 2000; World Spider Catalog, 2020; Zyuzin & Logunov, 2000): viz., the trans-Palaearctic *Alopecosa fabrilis* (Clerck, 1757), the eastern European - Central Asian *Allohogna singoriensis* (Laxmann, 1770) and the east-Mediterranean - Central Asian *Lycosa praegrandis* C.L. Koch, 1836. However, the taxonomy and distributional ranges of all of them are still in need of revision (e.g., see comments at the end of Table 1). Two common species are restricted to the eastern geographic limits of Europe only: *Geolycosa dunini* Zyuzin & Logunov, 2000 known from Transcaucasia (see Otto, 2020) and *Karakumosa shmatkoi* sp. nov. known from the eastern Caucasus and cis-Caspian regions (present data).

Among the Central Asian fossorial lycosids (Table 1) 13 species (42%) are only known from the respective type localities and/or the original descriptions. This can partly be attributed to the inadequate knowledge of Central Asian Lycosidae, but it could also reflect the presence of truly restricted ranges in many fossorial lycosids (e.g., McCrone, 1963; Fairweather, 1993; Marshall, 1995; etc.) as a result of their lower vagility and habitat specificity. These species are often confined to certain (semi)desert habitat types. In the absence of further survey data to clarify biogeographical and biological information about the majority of fossorial lycosids from Central Asia, except for *A. singoriensis* (see Wagner, 1868; Marikovski, 1956), the underlying causes of currently recognized localised distribution patterns in these spiders will remain unresolved.

Some earlier records of fossorial lycosids from that region are doubtful. For instance, *Hogna bergsoei* was described (but not illustrated) by Thorell (1875a: sub *Tarentula bergsoei*) from a single male from Derbent (Dagestan). Later it was reported from Baku (Azerbaijan) (L. Koch, 1878: sub *Lycosa bergsoei*). Based only on similarity in the body colouration of the five studied females from Turkmenistan (Kuldzha, Ashgabat and Kyzylkum desert) and the type described by Thorell, Schmidt (1895: 447) unreasonably identified and described them as *H. bergsoei*. Almost a hundred years later Dunin (1984) confirmed the occurrence of *H. bergsoei* in the Absheron Peninsula (Azerbaijan), but provided no illustration of the specimens he had studied. Neither Dunin (1984) nor previous authors explained how they were able to identify this species without a re-examination of its type. Despite the fact that these records have been accepted by some regional spider catalogues (Abdurakhmanov *et al.*, 2012; Mikhailov, 2013) and by the World Spider Catalog (2020) giving the distribution of this species as 'Caucasus (Russia, Azerbaijan), Central Asia', it is obvious that the taxonomic validity and all post-description records of *H. bergsoei* are in need of revision.

The case of *Vesubia vivax* (Thorell, 1875a) is similar

Table 1. The fossorial Lycosidae of Central Asia and their distribution.

Genera and species	Known sexes	Distribution	References
***Allohogna* Roewer, 1955a**			
A. singoriensis (Laxmann, 1770)	♂♀	European part of Russia to NW China (Xinjiang) and Inner Mongolia, southward to Iran	Marusik *et al.* (2000), Zamani *et al.* (2020)
***Alopecosa* Simon, 1885**			
A. fabrilis (Clerck, 1757)	♂♀	Trans-Palaearctic*	World Spider Catalog (2020)
A. marikovskyi Logunov, 2013	♂♀	SE Kazakhstan (TL)	Logunov (2013)
Geolycosa* Montgomery, 1904*			
G. dunini Zyuzin & Logunov, 2000	♂♀	Georgia, Armenia, Azerbaijan (TL)	Otto (2020), Zyuzin & Logunov (2000)
G. vultuosa (C.L. Koch, 1838)	♂♀	S and SE Europe, the Caucasus, Asia Minor, N Iran	Otto (2020), World Spider Catalog (2020), Zamani *et al.* (2020)
***Hogna* Simon, 1885**			
H. bergsoei (Thorell, 1875a)***	♂♀	Dagestan (TL), E Azerbaijan, Turkmenistan	Thorell (1875a, b), Schmidt (1895), Dunin (1984)
***Karakumosa* gen. nov.**			
K. alticeps (Kroneberg, 1875)	♂♀	SE Kazakhstan (TL)	Kroneberg (1875); present data
K. badkhyzica sp. nov.	♂♀	S Turkmenistan (TL)	Present data
K. gromovi sp. nov.	♂♀	S Uzbekistan (TL)	Present data
K. medica (Pocock, 1889)	♂♀	NW Afghanistan (TL)	Pocock (1889); present data
K. repetek sp. nov.	♂♀	E Turkmenistan (TL)	Present data
K. shmatkoi sp. nov.	♂♀	Azerbaijan, N cis-Caspian regions (TL)	Present data
K. tashkumyr sp. nov.	♂♀	Kyrgyzstan (TL)	Present data
K. turanica sp. nov.	♂♀	Turkmenistan (TL), SE Uzbekistan	Present data
K. zyuzini sp. nov.	♂♀	Uzbekistan (TL)	Present data
Lycosa* Latreille, 1804***			
L. aragogi Nadolny & Zamani, 2017	♀	C Iran (TL)	Nadolny & Zamani (2017)
L. asiatica Sytshevskaja, 1980	♂♀	Tajikistan (TL)	Sytshevskaja (1980)
L. praegrandis C.L. Koch, 1836	♂♀	E Mediterranean to Central Asia	Zyuzin & Logunov (2000)
***Oculicosa* Zyuzin, 1993**			
O. supermirabilis Zyuzin, 1993	♂♀	SW and SE Kazakhstan (TL), W Uzbekistan and NW Turkmenistan	Zyuzin (1993), Logunov & Gromov (2011)
***Vesubia* Simon, 1910**			
V. vivax (Thorell, 1875a)***	♂♀	European part of Russia, NW Uzbekistan	Thorell (1875a,b), Schmidt (1895)
***Zyuzicosa* Logunov, 2010**			
Z. afghana (Roewer, 1960)	♀	NE Afghanistan (TL)	Roewer (1960), Logunov (2010)
Z. baisunica Logunov, 2010	♂♀	SE Uzbekistan (TL)	Logunov (2010)
Z. fulviventris (Kroneberg, 1875)	♂♀	SE Uzbekistan (TL)	Kroneberg (1875), Logunov (2010)
Z. gigantea Logunov, 2010	♂	SE Uzbekistan (TL)	Logunov (2010)
Z. kopetdaghensis Logunov, 2012	♀	SW Turkmenistan (TL)	Logunov (2012)
Z. laetabunda (Spassky, 1941)	♂♀	Tajikistan (TL)	Spassky (1941), Spassky & Luppova (1945), Andreeva (1976), Logunov (2010, 2012)

Genera and species	Known sexes	Distribution	References
Z. nenjukovi (Spassky, 1952)	♂♀	Tajikistan (TL)	Spassky (1952), Andreeva (1976), Logunov (2012)
Z. nessovi Logunov, 2012	♂♀	Kyrgyzstan (TL)	Logunov (2012)
Z. turlanica Logunov, 2010	♂♀	S Kazakhstan (TL), SE Uzbekistan	Logunov (2010, 2012)
Z. uzbekistanica Logunov, 2010	♂♀	SE Uzbekistan (TL)	Logunov (2010, 2012)

* Although the distribution of *A. fabrilis* is given in World Spider Catalog (2020) as trans-Palaearctic, it is likely that all the records of this species from southern regions of European Russia and central Asia actually belong either to *Alopecosa steppica* Ponomarev, 2007 or to *A. psammophila* Buchar, 2001. This matter requires special attention in the future.

** *Geolycosa atroscopulata* Roewer, 1955a, described and recorded from northern Iran, is not a true member of the genus *Geolycosa* and therefore is excluded from the list of fossorial lycosids.

*** At present, there is no evidence that this species is indeed fossorial, but other congeners of this genus are.

**** The record of *Lycosa tarantula* (Linnaeus, 1758) from Iran (see Zamani *et al.*, 2020) beyond doubt is based on a misidentification and hence is not included in Table 1. According to Planas *et al.* (2013), *L. tarantula* is restricted to the northern part of the West Mediterranean, occurring from France to Italy.

to that of *H. bergsoei*. The species was described by Thorell (1875a, b: sub. *Tarentula vivax*) from a single female taken from an unknown locality in 'Südrussland' (German: southern Russia). Later Schmidt (1895: 457, sub *Lycosa vivax*) recorded this species from Nukus (Uzbekistan) on the basis of a male and female which he decided to be "in complete agreement with Thorell's description" apart from some varying measurements. It is unclear why the World Spider Catalog (2020) lists the distribution of *V. vivax* as 'Ukraine, Russia (Europe), Turkmenistan (?)', since neither Ukraine nor Turkmenistan were mentioned in any papers dealing with this species. As in the previous example, the taxonomic validity and the post-description records of *V. vivax* are in need of revision. Based on unpublished information from the colleague who re-examined the holotype of *V. vivax* (Yu. M. Marusik, personal communication, 27 March 2020), this species is actually a member of the genus *Alopecosa*.

ACKNOWLEDGEMENTS

We are most grateful to the following colleagues who provided help during the preparation of the present work: Mr Alexander V. Gromov (Bingen-am-Rhein, Germany) and Dr Alexei A. Zyuzin (Almaty, Kazakhstan) for tracing some localities of the studied species, Dr Anton A. Nadolny (Sevastopol, Russia) for critical commenting on an earlier draft of the manuscript, Dr Yuri M. Marusik (Magadan, Russia) for taking some SEM micrographs and digital photos (Figs 9-11, 17-21) and for critical comments on the early manuscript version, Dr Galina N. Azarkina (Novosibirsk, Russia) for producing the maps (Figs 76, 149) and commenting on an early manuscript version, Mr Tony Hunter (Liverpool, UK) for allowing one of us (DVL) to use the digital facilities at the World Museums of Liverpool (UK), Mr Phillip Rispin (Manchester, UK) for help with digital photography of three *Karakumosa* species (Figs 22-26, 113-114, 150-154), and Mr Alexander A. Fomichev (Novosibirsk, Russia) for sharing additional records of *K. alticeps* and allowing us to use some of his digital photos (Figs 12-16). We also wish to sincerely thank Mr Vladimir Yu. Shmatko and Mr Alexander V. Nazarenko (both Rostov-on-Don, Russia) for their kind assistance and help with producing most of the digital photos and SEM micrographs. Finally, Drs Volker W. Framenau (Murdoch, Australia) and Peter J. Schwendinger (Geneva, Switzerland) are acknowledged for their critical comments that help to improve the final manuscript version.

The research by the second author (AVP) was conducted within the framework of the state task to the Southern Scientific Centre of the Russian Academy of Sciences, under project no. AAAA-A19-119011190176-7.

REFERENCES

Abdurakhmanov G.M., Ponomarev A.V., Alieva S.V. 2012. Spiders (Arachnida: Aranei) of the Republic of Dagestan: species composition and distribution. *Makhachkala, DGPU,* 220 pp. [In Russian]

Aitchison J.E.T. 1889. Introduction. *In*: Aitchison J.E.T. (ed.), The zoology of the Afghan Delimitation Commission. *Transactions of the Linnean Society of London* (Zoology, 2) 5(3): 53-55.

Alderweireldt M., Jocqué R. 1991. A remarkable new genus of wolf spiders from southwestern Spain (Araneae, Lycosidae). *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Entomologie* 61: 103-111.

Andreeva E.M. 1975. Distribution and ecology of spiders (Aranei) in Tajikistan. *Fragmenta faunistica* 20(19): 323-352.

Andreeva E.M. 1976. Spiders of Tajikistan. *Donish, Dushanbe,* 196 pp. [In Russian]

Buchar J. 2001. Two new species of the genus *Alopecosa* (Araneae: Lycosidae) from south-eastern Europe. *Acta Universitatis Carolinae Biologica* 45: 257-266.

Cameron H.D. 2005. An etymological dictionary of North American spider genus names [pp. 274-330]. *In*: Ubick D., Paquin P., Cushing P.E., Roth V. (eds), Spiders of North America: an identification manual. *American Arachnological Society, Keene, NH*, 377 pp.

Clerck C. 1757. Svenska spindlar, uti sina hufvud-slågter indelte samt under några och sextio särskildte arter beskrefne och med illuminerade figurer uplyste. *Literis Laur. Salvii, Stockholmiae*, 154 pp.

Dondale C.D. 1986. The subfamilies of wolf spiders (Araneae: Lycosidae) [pp. 327-332]. *In*: Barrientos J.A. (ed.), Actas X. Congreso Internacional de Aracnología, Jaca, España, Volume I. *Juvenil, Barcelona,* 73 pp.

Dunin P.M. 1984. Fauna and ecology of spiders (Aranei) of Apsheron Peninsula [pp. 45-60]. *In*: Utochkin A.S. *et al.* (eds), Fauna i ekologiya paukoobraznykh. *PGU Press, Perm*, 159 pp. [In Russian]

Fairweather P.G. 1993. Abundance and structure of fossorial spider populations. *Memoirs of the Queensland Museum* 33(2): 513-518.

Griswold C.E. 1993. Investigations into the phylogeny of the lycosoid spiders and their kin (Arachnida: Araneae: Lycosoidea). *Smithsonian Contributions to Zoology*, 539: 1-39.

Koch C.L. 1836. Die Arachniden. Dritter Band. *C.H. Zeh'sche Buchhandlung Nürnberg,* pp. 1-104, pl. 73-105, figs 164-245.

Koch C.L. 1838. Die Arachniden. Fünfter Band. *C.H. Zeh'sche Buchhandlung, Nürnberg,* pp. 1-124, pl. 145-174, figs 340-417.

Koch L. 1878. Kaukasische Arachnoideen [pp. 9-71]. *In*: Schneider O. (ed.), Naturwissenschaftliche Beiträge zur Kenntniss der Kaukasusländer auf Grund seiner Sammelausbeute. Sitzungsberichte der Naturforschenden Gesellschaft. *ISIS, Dresden*, 159 pp.

Kroneberg A.I. 1875. Puteshestvie v Turkestan A.P. Fedtschenko. Pauki. Araneae [A.P. Fedtschenko. Voyage in Turkestan. Spiders. Araneae]. *Izvestiya Obschestva lyubitelei estestvoznaniya, antropologii i etnografii* 19(3): I-IV, 1-55. [In Russian]

Kryzhanovsky O.L. 2002. Composition and distribution of entomofaunas of the globe. *KMK Sci. Press, Moscow*, 237 pp. [In Russian]

Latreille P.A. 1804. Tableau méthodique des Insectes. *Nouveau Dictionnaire d'Histoire Naturelle, Paris* 24: 129-295.

Laxmann E. 1770. Novae insectorum species. *Novi Commentarii Academiae Scientiarum Imperialis Petropolitanae* 14: 593-604.

Linnaeus C. 1758. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species cum characteribus differentiis, synonymis, locis. Editio decima, reformata. *Impensis Direct. Laurentii Salvii, Holmiae*, 821 pp.

Logunov D.V. 2010. On new central Asian genus and species of wolf spiders (Araneae: Lycosidae) exhibiting a pronounced sexual size dimorphism. *Proceedings of the Zoological Institute RAS* 314(3): 233-263.

Logunov D.V. 2012. A synopsis of the genus *Zyuzicosa* Logunov, 2010 (Aranei: Lycosidae). *Arthropoda Selecta* 21(4): 349-362.

Logunov D.V. 2013. A new species of the genus *Alopecosa* Simon, 1885 (Aranei: Lycosidae) from south-east Kazakhstan. *Arthropoda Selecta* 22(2): 163-169.

Logunov D.V., Gromov A.V. 2011. Notes on the distribution of *Oculicosa supermirabilis* (Araneae, Lycosidae). *Arachnologische Mitteilungen* 42: 48-51.

Marikovski P.I. 1956. Tarantul and Karakurt. *AN KirgSSR, Frunze*, 281 pp. [In Russian]

Marshall S.D. 1995. Natural history, activity patterns, and relocation rates of a burrowing wolf spider: *Geolycosa xera archboldi* (Araneae, Lycosidae). *Journal of Arachnology* 23: 65-70.

Marusik Yu.M., Logunov D.V., Koponen S. 2000. Spiders of Tuva, South Siberia. *IBPN, Magadan*, 252 pp.

McCrone J.D. 1963. Taxonomic status and evolutionary history of the *Geolycosa pikei* complex in the southeastern United States (Araneae, Lycosidae). *The American Midland Naturalist* 70(1): 47-73.

Mikhailov K.G. 2013. The spiders (Arachnida: Aranei) of Russia and adjacent countries: a non-annotated checklist. *Arthropoda Selecta* Supplement 3: 1-262.

Mikhailov K.G., Fet V.Ya. 1994. Fauna and zoogeography of spiders (Aranei) of Turkmenistan [pp. 499-524]. *In*: Fet V. & Atamuradov K.I. (eds), Biogeography and ecology of Turkmenistan. *Kluwer Acad. Publ., Dordrecht/Boston/ London*, 650 pp.

Minoransky V.A., Ponomarev A.V. 1984. Materials on the spider fauna of Kamykia [pp. 82-92]. *In*: Utochkin A.S. *et al.* (eds), Fauna i ekologiya paukoobraznykh. *PGU Press, Perm*, 159 pp. [In Russian]

Montgomery T.H. 1904. Descriptions of North American Araneae of the families Lycosidae and Pisauridae. *Proceedings of the Academy of Natural Sciences of Philadelphia* 56: 261-325.

Murphy N.P., Framenau V.W., Donnellan S.C., Harvey M.S., Park Y.C., Austin A.D. 2006. Phylogenetic reconstruction of the wolf spiders (Araneae: Lycosidae) using sequences from the 12S rRNA, 28S rRNA, and NADH1 genes: implications for classification, biogeography, and the evolution of web building behaviour. *Molecular Phylogenetics and Evolution* 28: 583-602.

Nadolny A.A., Zamani A. 2017. A new species of burrowing wolf spiders (Araneae: Lycosidae: *Lycosa*) from Iran. *Zootaxa* 4286(4): 597-400.

Nentwig W., Blick T., Bosmans R., Gloor D., Hänggi A., Kropf C. 2020. Araneae, spiders of Europe. Version 04.2020. Available at https://www.araneae.nmbe.ch (accessed on 20 April 2020). https://doi.org/10.24436/1

Otto S. 2020. Caucasian Spiders. A faunistic database on the spiders of the Caucasus. Version 10.2019. Available at https://caucasus-spiders.info/ (accessed on 20 April 2020).

Ovtsharenko V.I., Fet V.Ya. 1980. Fauna and ecology of spiders (Aranei) of Badkhyz (Turkmenian SSR). *Entomologicheskoe obozrenie* 59(2): 442-447. [In Russian]

Parker J.R. 1980. Arachnological history: what's in a name? Part II, specific names. *Newsletters of the British arachnological Society* 28: 1-7.

Piacentini L.N., Ramírez M.J. 2019. Hunting the wolf: a molecular phylogeny of the wolf spiders (Araneae, Lycosidae). *Molecular Phylogenetics and Evolution* 136: 227-240.

Planas E., Fernández-Montraveta C., Ribera C. 2013. Molecular systematics of the wolf spider genus *Lycosa* (Araneae:

Lycosidae) in the western Mediterranean basin. *Molecular Phylogenetics and Evolution* 67: 414-428.
Pocock R.I. 1889. Arachnida, Chilopoda and Crustacea. *In*: Aitchison J.E.T. (ed.), The zoology of the Afghan Delimitation Commission. *Transactions of the Linnean Society of London* (Zoology, 2) 5(3): 110-121, pl. 13.
Ponomarev A.V. 2007. New taxa of spiders (Aranei) from the south of Russia and western Kazakhstan. *Caucasian Entomological Bulletin* 3: 87-95. [In Russian]
Ponomarev A.V. & Abdurakhmanov G.M. 2014. Spiders (Aranei) of the shore and islands of the northern part of Caspian Sea. *The South of Russia: Ecology and Development* 1: 76-121. [In Russian]
Pravdin F.N. 1978. Ecological geography of insects of Middle Asia, orthopteroids. *Nauka, Moscow*, 185 pp. [In Russian]
Pravdin F.N., Mishchenko L.L. 1980. Formation and evolution of ecological insect faunas in Middle Asia. *Nauka, Moscow*, 156 pp. [In Russian]
Roewer C.F. 1955a. Die Araneen der Österreichischen Iran-Expedition 1949/50. *Sitzungsberichte der österreichische Akademie der Wissenschaften, mathematisch-natur-wissenschaftliche Klasse, Abteilung I* 164(9): 751-782.
Roewer C.F. 1955b. Katalog der Araneae von 1758 bis 1940, bzw. 1954. 2. Band, Abt. a (Lycosaeformia, Dionycha [excl. Salticiformia]). 2. Band, Abt. b (Salticiformia, Cribellata) (Synonyma-Verzeichnis, Gesamtindex). *Institut royal des Sciences naturelles de Belgique, Bruxelles*, 1751 pp.
Roewer C.F. 1960. Lycosidae aus Afghanistan (Araneae). *Lunds Universitets Årsskrift (N.F.)* (2) 56(17): 1-34.
Schmidt P. 1895. Beitrag zur Kenntnis der Laufspinnen (Araneae Citigradae Thor.) Russlands. *Zoologische Jahrbücher, Abtheilung für Systematik, Geographie und Biologie der Thiere* 8(4): 439-484.
Shorthouse D.P. 2010. SimpleMappr, an online tool to produce publication-quality point maps. Available at http://www.simplemappr.net (accessed on 6 March 2020).
Simon E. 1876. Etudes arachnologiques. 4e mémoire. VII. Révision des espèces européennes du groupe de la *Lycosa tarentula* Rossi. *Annales de la Société Entomologique de France* (5)6: 57-91.
Simon E. 1885. Etudes sur les Arachnides recueillis en Tunisie en 1883 et 1884 par MM. A. Letourneux, M. Sédillot et Valéry Mayet, membres de la mission de l'Exploration scientifique de la Tunisie. *Imprimerie nationale, Paris*, 55 pp.
Simon E. 1899. Araneae Transcaspicae. *In*: Radde G.I. (ed.), *Kollektsii Kavkazskogo Muzeya (Museum Caucasicum), Tiflis: Zoologhiya* 1: 478-480.
Simon E. 1910. Arachnides recueillis par L. Fea sur la côte occidentale d'Afrique. 2e partie. *Annali del Museo Civico di Storia Naturale di Genova* 44: 335-449.
Song D.X., Zhu M.S., Chen J. 1999. The spiders of China. *Hebei Science and Technology Publishing House, Shijiazhuang*, 640 pp.
Spassky S.A. 1941. Araneae palaearcticae novae. VI. *Strand's Folia Zoologica et Hydrobiologica* 11(1): 13-27.
Spassky S.A. 1952. Spiders of the Turan zoogeographic province. *Entomologicheskoe Obozrenie* 32: 192-205. [In Russian]
Spassky S.A., Luppova E. 1945. Materials on the spider fauna of Tajikistan. *Revue d'Entomologie de l'URSS* 27(1-2): 43-55. [In Russian]
Sundevall C.J. 1833. Svenska spindlarnes beskrifning. Fortsättning och slut. *Bihang till Kongliga Svenska Vetenskaps-Akademiens Handlingar* 1832: 172-272.
Sytshevskaya V.I. 1980. A new species of the genus *Lycosa* Latr. (Aranei, Lycosidae) from Tajikistan. *Entomological Review* 59(1): 229-232. [In Russian]
Thorell T. 1875a. Verzeichniss südrussischer Spinnen. *Horae Societatis Entomologicae Rossicae* 11: 39-122.
Thorell T. 1875b. Descriptions of several European and North African spiders. *Kongliga Svenska Vetenskaps-Akademiens Handlingar* 13(5): 1-204.
Vlassov J.P., Sytshevskaja V.I. 1937. The spiders of the neighbourhood of Ashkhabad. *Trudy Soveta po Izuceniju Proizvoditeljnych Sil, Serija Turkmenskaja* 9: 247-258. [In Russian]
Wagner N.P. 1868. Observations on the tarantula (*Lycosa latreillei* Koch) occurring in Russia. *Trudy I s'ezda russkikh estestvoispytatelei, Otdelenie zoologii, Saint-Petersburg* 1868: 240-262. [In Russian]
World Spider Catalog 2020. World Spider Catalog. Version 21.0. Natural History Museum Bern. Available at http://wsc.nmbe.ch (accessed on 20 April 2020). doi: 10.24436/2
Zamani A., Mirshamsi O., Marusik Yu.M., Moradmand M. 2020. The checklist of the spiders of Iran. Version 2020. Available at http://www.spiders.ir (accessed on 23 March 2020).
Zyuzin A.A. 1990. Studies on burrowing spiders of the family Lycosidae (Araneae). I. Preliminary data on structural and functional features. *Acta Zoologica Fennica* 190: 419-422.
Zyuzin A.A. 1993. Studies on the wolf spiders (Araneae: Lycosidae). I. A new genus and new species from Kazakhstan, with comments on the Lycosinae. *Memoirs of the Queensland Museum* 33(2): 693-700.
Zyuzin A.A., Logunov D.V. 2000. New and little-known species of the Lycosidae from Azerbaijan, the Caucasus (Araneae, Lycosidae). *Bulletin of the British arachnological Society* 11(8): 305-319.
Zyuzin A.A., Tarabaev C.K., Feodorov A.A. 1994. The spiders (Arachnida: Araneae) collected in the eastern part of Kyzylkum Desert and the eastern surroundings of Aral Sea. *Selevinia* 1: 3-11. [In Russian]

Revue suisse de Zoologie (September 2020) 127(2): 315-339 ISSN 0035-418

Mayfly types and additional material (Insecta: Ephemeroptera) examined by F.-J. Pictet and A.-E. Pictet, housed in the Museums of Natural History of Geneva and Vienna

Michel Sartori[1,2,*] & Ernst Bauernfeind[3]

[1] *Musée cantonal de zoologie, Palais de Rumine, Place Riponne 6, CH-1005 Lausanne, Suisse.*
[2] *Département d'Ecologie et d'Evolution, Biophore, Université de Lausanne, CH-1015 Lausanne, Suisse.*
[3] *Naturhistorisches Museum Wien, Burgring 7, A-1010 Wien, Österreich. E-mail: ernst.bauernfeind@nhm-wien.ac.at*
* *Corresponding author: michel.sartori@vd.ch*

Abstract: Here we revise the entire Ephemeroptera collection of F.-J. Pictet deposited in the Natural History Museum of Geneva (MHNG) and voucher specimens housed in the Natural History Museum of Vienna (NMW). Due to several unforeseen turns of events, the MHNG collection was already in bad condition at the end of the 19th century. However, the specimens sent by V. Kollar to F.-J. Pictet, and used by the latter for his monograph (1843-1845), have been well curated after their return to the NMW and allow an important nomenclatural change. The species *Baetis forcipula* F.-J. Pictet, 1843 is now considered a junior subjective synonym of *Ephemera venosa* Fabricius, 1775, currently *Ecdyonurus (Ecdyonurus) venosus* (Fabricius, 1775). The specimens described by Thomas in 1968b from southwestern France under the name *Ecdyonurus forcipula* (F.-J. Pictet, 1843) belong to a new species, *Ecdyonurus alaini* Bauernfeind sp. nov., which is described herein. Mayfly specimens described by F.-J. Pictet's son, A.-E. Pictet, are also reviewed. Furthermore, information is provided on some other valuable specimens housed in the MHNG and NMW, such as *Ametropus fragilis* Albarda, 1878 which was already collected in Italy in the 19th century, or *Rhithrogena cincta* Navás, 1921 from the Spanish Pyrenees, which is the second specimen currently known of this species.

Keywords: Ephemeroptera - taxonomy - type material - new species - new combination.

INTRODUCTION

The book "Histoire naturelle générale et particulière des Insectes Névroptères. Famille des Ephémérines" written by F.-J. Pictet (text volume published in 1843, plates volume in 1845) is considered the first modern synthesis of this insect order (Peters *et al.*, 1980). It followed two other monographs published by the same author in 1834 on Trichoptera and in 1841-1842 on Plecoptera. In his work on Ephemeroptera, F.-J. Pictet gives an account of the morphology of these insects, the characters to be used for their identification and mentions all species known at that time. His monograph encompasses the detailed descriptions of 54 species placed in seven genera only: *Ephemera* Linnaeus, 1758, *Palingenia* Burmeister, 1839, *Baetis* Leach, 1815, *Potamanthus* F.-J. Pictet, 1843, *Cloë* Burmeister, 1839, *Caenis* Stephens, 1836 and *Oligoneuria* F.-J. Pictet, 1843. Eaton published the framework for the modern systematics of supraspecific taxa later in his numerous contributions to Ephemeroptera and in his monograph (Eaton, 1883-1888).

Among the 54 species mentioned in F.-J. Pictet's work, 33 were described as new for science. The material used for these descriptions had two origins: First, the specimens he had collected himself or those he had found in the collection of the Natural History Museum of Geneva (MHNG); these he described in his monograph and the species name is followed by the Latin word "Mihi", i.e. "mine". The second source were the specimens and a "manuscript" (presumably rather a list of names proposed by Kollar) sent by Vincenz Kollar from the Natural History Museum of Vienna. F.-J. Pictet acknowledged Kollar's contribution by giving these new species the names Kollar had proposed. These names are followed in the monograph by the letters "Kollar. Mss." or "Koll. Mss.", but the author, according to article 50.1 of the code of zoological nomenclature (International Commission on Zoological Nomenclature, 1999), is F.-J. Pictet. Part of the Kollar bequest is still housed at the Natural History Museum of Vienna (Dept. Archives of NMW). In a letter to Kollar, dated 7.6.1844, F.-J. Pictet confirmed the receipt of "un petit ballot intéressant des

Manuscript accepted 15.06.2020
DOI: 10.35929/RSZ.0022

insectes… de mes Perlides et Ephemérines". The material was sent back to Vienna after he had finished his study. F.-J. Pictet's own collection was kept at that time in the family mansion at Genthod, near Geneva.
Although less important, the contribution by his son, Albert-Edouard Pictet, is worth being mentioned. He published a monograph (A.-E. Pictet, 1865) in which he described, among other neuropteroid insects, two species of Ephemeroptera.

The Pictet Collection in the Natural History Museum of Geneva

The collection of the Pictets arrived at the Natural History Museum of Geneva in 1887. It presumably contained the original material used by the father and the son in their research. The collection was catalogued in 1892 and bears the number 620/48. Most of the pinned specimens possess a label with this code.
Currently the collection is in five insect boxes and contains 353 specimens. The first two boxes contain most of the material and most species. Two other boxes are smaller and contain a subset of one or two specimens of each species present in the first two boxes. The fifth box has labels of a different handwriting and is also a subset of selected species. As most of the specimens are labelled "coll. Pictet", they are considered in this catalogue although it is doubtful whether this is all part of the material seen either by F.-J. or A.-E. Pictet.
This collection has lost its originality to such an extent that it is difficult to recognise it as the one built up by F.-J. Pictet. The same had also been pointed out by Aubert (1947) and Zwick (1971) about the Plecoptera collection, as well as by Botosaneanu & Schmid (1973) about the Trichoptera collection of the MHNG. More dramatic is that most of the specimens studied by F.-J. Pictet are evidently lacking. Less than 10% of the specimens bear a label with a locality mentioned in his monograph, such as "Genthod" or "Genève", and only 7 specimens bear a label with the original handwriting of F.-J. Pictet. Most specimens have labels indicating that they originate from Burgdorf near Bern (often abbreviated "Bgdf") and were formerly part of Meyer-Dür's collection. Other specimens simply bear a label with "coll. Pictet" but without any locality written on them, and others just indicate "Europe" or "Europe centr[ale]".
There are other indications that this collection has been supplemented, possibly several times, after it arrived in the MHNG. Several specimens originate from places never mentioned by F.-J. Pictet, such as the Balkans, Turkey, England, and Swiss localities outside the Lake Geneva area (e.g. Burgdorf, Aarau, Bernina). Secondly, the person (or persons) who "rearranged" the collection was not a specialist on Ephemeroptera. There are several examples of incredible mixing of species. Among the 10 specimens labelled as "*Leptophlebia submarginata* Steph." one can find 7 *Paraleptophlebia submarginata*, 1 *Baetis rhodani*, 1 *Ecdyonurus venosus* and 1 *Ephemera glaucops*! There also are some *Baetis alpinus* among *Electrogena lateralis*, *Ephemera danica* among *Ecdyonurus venosus, Serratella ignita* among *Habrophlebia fusca* and so on. What happened to this collection? We have no solid information, but we can try to reconstruct its history.
François-Jules Pictet (1809-1872) (Fig. 1) married Eleonore de la Rive (1812-1887) in 1834 and had five children with her. The elder was Albert-Edouard Pictet (1835-1879) who was also an entomologist and who published a synopsis of Spanish Neuroptera (A.-E. Pictet, 1865). This work is based on a 4-months trip he made together with the Swiss entomologist Rudolf Meyer-Dür (1812-1885) in 1859. François-Jules' second son, Alphonse Pictet (1838-1903) is less known but was also an entomologist. Albert-Edouard Pictet married Emilie Mallet (1844-1897) in 1863, and together they had several children, the elder being Camille Pictet (1864-1893), a naturalist, who donated the collection to the MHNG in 1887.
Another important event in the history of this collection concerns F.-J. Pictet himself. His monograph on Ephemeroptera was in fact his last contribution to the extant neuropteroid insects on which he had been working since 1830. In 1844 he turned to palaeontology and published a number of important papers and treatises

Fig. 1. François-Jules Pictet de la Rive (1809-1872) in his library. Oil painting, without date or signature; attributed to a Mr Kaiser (according to an inscription on the back of the painting). Courtesy of the Fondation des Archives de la Famille Pictet, Geneva.

on that topic, including some fossil Ephemeroptera (F.-J. Pictet, 1846; F.-J. Pictet & Hagen, 1856). Supposedly his collection was subsequently left unused, his son Albert-Edouard being 10 years old at that time. According to information provided by Hagen (1859, cited by Meyer-Dür, 1874) "[F.-J.] Pictet's eigene Sammlung war zur jener Zeit schon längstens zerstört". Knowing the good relationships between Meyer-Dür and Albert-Edouard Pictet, one can suppose that it was at that time that F.-J. Pictet's collection was supplemented and rearranged with material given or sold by Meyer-Dür. In his obituary of Albert-Edouard Pictet, Saussure (1879) wrote: "Malheureusement Edouard Pictet n'a jamais terminé les autres travaux d'Entomologie qu'il avait entrepris. Il avait en lui l'étoffe d'un homme d'action, plutôt que celle d'un homme de cabinet" (Unfortunately, Edouard Pictet never finished the other entomological works [besides a monograph in 1865] he has undertaken. He was more a man of action than a scholar). This may explain, in part, the neglect of the collection.

Alfred Edwin Eaton (1844-1929) did see this collection at least two times. In his 1871 paper (Eaton, 1871: 2) he wrote "At Geneva, M. A.E. Pictet very kindly submitted to me *the remains* [our italics] of Professor J.F. [sic] Pictet's collection…". In the same text (Eaton, 1871: 11) he also stated more precisely: "As the authentic and spurious specimens are not distinguished in M. Pictet's collection, an accurate enumeration of them could not be made ". He is more precise when dealing with the species *Potamanthus ferreri* F.-J. Pictet, 1843 (see Eaton, 1883-1888: 80): "The unique specimen formerly in the Geneva Museum, was not there in 1867". He saw the collection a second time, probably in 1879. He wrote about *Leptophlebia cincta* (Retzius, 1783) (see Eaton, 1883-1888: 96): "Pictet probably confused this species with *Habrophlebia lauta* […] because it was mingled with a *Habrophlebia* in his collection, and is found in the neighbourhood of Geneva. In September 1879 I found both of these species beside a stream at Troinex, near Mt. Salève". When describing *Ephemerella hispanica* Eaton, 1888 in the same publication (Eaton, 1883-1888: 306), he noted that " [the specimens were] captured by Messrs Ed. Pictet and Meyer-Dür in the year 1859. […] I have lately examined all that remains of the Spanish Ephemeridae collected by the deceased Swiss entomologists above mentioned. […] part of a male imago in Ed. Pictet's Mus. but the ravages of *Anthrenus* preclude full description of the insect from these materials". The Pictet collection arrived at the Natural History Museum of Geneva in 1887 but was not catalogued until 1892. What happened in the meantime?

During the 20th century the remains of the collection were partially studied by several mayfly specialists. The first one was probably Kimmins (1936) when dealing with the problematic species *Rhithrogena semicolorata* (Curtis, 1834) and *R. semitincta* (F.-J. Pictet, 1843). Thomas (1968b) later solved the problem of *Ecdyonurus fluminum* (F.-J. Pictet, 1843), then Sowa (1971) cleared up the status of *Rhithrogena semitincta*. In three publications Puthz also revised part of the collection, i.e. *Epeorus sylvicola* (A.-E. Pictet, 1865) (see Puthz, 1973c), *Rhithrogena picteti* Sowa, 1971 (see Puthz, 1975) and *Siphlonurus flavidus* (A.-E. Pictet, 1865) (see Puthz, 1977). Later, Sartori and co-workers cited some material from this collection (Sartori *et al.*, 1989, 1996).

A short history of the entomological collection at the Natural History Museum of Vienna

The Vienna Entomological Collection dates back to 1793, when the German Emperor Franz II. (Franz I. of Austria after 1806) acquired a collection of insects and birds from Josef Natterer sen. A separate department of insects (within the so called "Vereinigtes Naturalien-Cabinet") was first established officially on May 2nd, 1802, when Johann Georg Megerle was appointed amanuensis for this collection. When Vincenz Kollar (1797-1860) systematically re-arranged the entomological collection between 1817 and 1820, its holdings included, among others, the following important collections: Johann Christian Gerning (1745-1802) Coll., acquired in 1796 (European Lepidoptera); Ludwig Heinrich v. Block (1764-? 1818) Coll., acquired in 1797 (insects and Arachnida); Leopold v. Fichtel (1770-1810) Coll., acquired in 1804, 1807 (East India, mainly Lepidoptera); Nepomuk C. M. Denis (1729-1800) & Ignaz Schiffermüller (1727-1806) Coll., acquired in 1806 (Austrian Lepidoptera, destroyed by fire in 1848); Johann Carl Megerle v. Mühlfeld (1765-1832) Coll., acquired in 1808 (all insect orders); Johann Natterer (1787-1843) Coll., acquired 1818-1838 (Brazil, all insect orders). Between 1836 and 1839 the collection was again revised by Kollar, adopting Latreille's system, and (most probably) in this time fell his main contact with François-Jules Pictet.

Only few collectors, most prominent among them Josef Johann Mann (1804-1889), V. Kollar, J. Natterer, Emerich Frivaldszky (1799-1870) and Johann Lhotsky (1795-1866), had contributed Ephemeroptera specimens, and acquisitions remained rather casual in later decades too. Friedrich Moritz Brauer (1832-1904), curator since 1876, collected some specimens during the Novara-Expedition (1857-1859) and also on several excursions in Austria. Other collectors contributing Ephemeroptera from Austria include Ludwig Redtenbacher (1814-1876), Alois Rogenhofer (1831-1897), Hans Rebel (1861-1940), Anton Handlirsch (1865-1935), Peter Kempny (1862-1906), Hans Fruhstorfer (1866-1922), Franz Werner (1867-1939) and Egon Galvagni (1874-1955). Hans Zerny (1887-1945) collected many interesting specimens mainly in Austria, Spain and in the Balkans, material from Poland (Friedrich Kolenati, 1812-1894) and Greece (Theobald Krüper, 1829-1921) was purchased in 1847 and 1869, respectively.

Since F.-J. Pictet, only few scientists used the collection for new descriptions or revisions: Brauer (in Brauer & Löw, 1857) described *Ephemerella mesoleuca* and later published several faunistic records for Ephemeroptera (Brauer, 1876, 1878, 1885). Georg Ulmer revised the collection before 1919, describing *Paraleptophlebia werneri* (Ulmer, 1920a) and later redescribed several taxa from type material housed at that time in the NMW and elsewhere (Ulmer, 1921). Parts of the collection (western Palaearctic taxa) have been studied by Volker Puthz in 1971 and 1973. For his revision of European taxa of the family Caenidae (Malzacher, 1984, 1986), Peter Malzacher checked the respective material in 1983. Between 1985 and 1990 Ernst Bauernfeind catalogued the collection (in manuscript), established an annotated Austrian check-list (Bauernfeind, 1990) based in part on NMW material, and described *Rhithrogena zernyi* Bauernfeind, 1991 from material collected by H. Zerny in Bosnia-Herzegovina in 1929.

Presently the Ephemeroptera collection at the Natural History Museum of Vienna consists of pinned specimens, a small collection of material preserved in alcohol (in part derived from originally pinned specimens) and a small collection of microscopic slides. Associated with the historic collection is the second author's collection (alcohol material and slides). For the pinned specimens, originally no identifications had been given on individual labels, the scientific name was provided separately at the head of each column of specimens within each entomological drawer. Only in a few cases the first specimen of a series carried a collector's label, and specimens originating from the same date and locality could only be distinguished by their grouping. However, subsequent changes in the arrangement (due to nomenclatural changes or prior misidentifications) did not always respect this principle and consequently assignment of original identification and label data to specimens has sometimes been rendered rather difficult. Fortunately no problems of that kind were observed concerning the specimens examined by F.-J. Pictet, which have all been carefully marked with the handwritten label: Pictet vidit (Kollar's handwriting).

Ephemeroptera form a rather insignificant part of the very large entomological collections and have been incorporated into the so called appended collections within the "insecta varia". Data concerning collections and their date of acquisition have mostly been compiled from Fitzinger (1868a, b, 1880a, b) and from the card files of collectors in the bird department of the NMW. Helpful information on biographies has also been derived from the collector's data bases at the German Entomological Institute (available at *sdei.senckenberg.de/biographies/*) and at the Oberösterreichisches Landesmuseum (*www.zobodat.at/personen.php*).

MAYFLY TAXA DESCRIBED BY FRANÇOIS-JULES PICTET

In the following list – if available – the status, sex, literally transcription of label data and condition are provided for all specimens. Different labels are indicated by strokes, additional remarks are between square brackets. The order of presentation follows the one adopted by F.-J. Pictet in his monograph (F.-J. Pictet, 1843) and using the original names as title. The currently accepted name is given separately.

Ephemera glaucops F.-J. Pictet, 1843

Fig. 2

Ephemera glaucops F.-J. Pictet, 1843-1845: 132-134, pl. 8, figs 1-3.

Accepted name: *Ephemera glaucops* F.-J. Pictet, 1843.

Locus typicus: "… Genève au bord du lac…".

Type material: MHNG; syntype, ♂ imago; 620 Genthod 48 Genève, coll. Pictet / Gthod, 27.7 [written by F.-J. Pictet, probably giving the place (Genthod) and the date (July 27) of collecting]. – MHNG; syntype, ♂ imago bearing 4 labels (Fig. 2): 620 Genthod 48 Genève, coll. Pictet / *Eph[emera] glaucops* ♂ imago [F.-J. Pictet's handwriting] / Gthd 21.7 [Pictet's handwriting]/ *Ephemera glaucops* Pictet 1843 M. Sartori det. 1996. – MHNG; syntype, ♀ imago; 620 Genthod

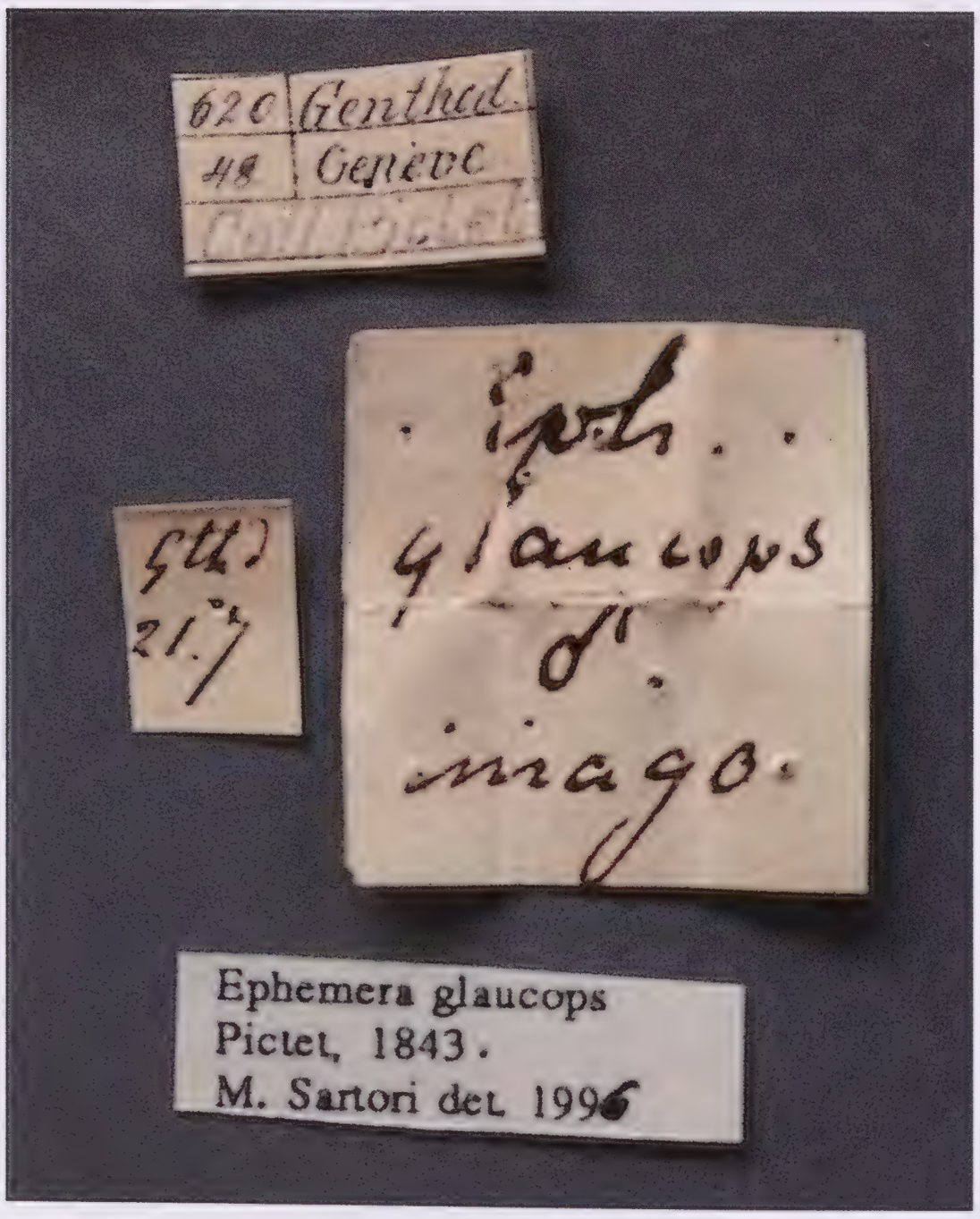


Fig. 2. *Ephemera glaucops* F.-J. Pictet, 1843, labels of one male imago syntype.

48 Genève, coll. Pictet / G[en]thod, 27.7 [F.-J. Pictet's handwriting]. – MHNG; syntype, ♀ imago; 620 Genthod 48 Genève, coll. Pictet / G[en]thod, 21.7 [F.-J. Pictet's handwriting].

Remarks: This is the best series at the MHNG. Besides numerous subsequent misidentifications, there are 4 specimens that still bear a label handwritten by F.-J. Pictet and that were collected at Genthod, near Geneva. Only these 4 specimens can be considered syntypes of *E. glaucops*.

Ephemera guttulata F.-J. Pictet, 1843

Ephemera guttulata F.-J. Pictet, 1843-1845: 135, pl. 8, fig. 4.

Accepted name: *Ephemera guttulata* F.-J. Pictet, 1843.

Locus typicus: Not mentioned [North America].

Type material: Holotype [by monotypy], presumably a male imago (Eaton, 1871: 70). Not in MHNG, not traced.

Remarks: F.-J. Pictet mentioned that the single specimen he saw came from the collection of the Museum of Natural History in Neuchâtel and had been made accessible by M. Coulon. According to Dr Jean-Paul Haenni (in litt.), former curator at the Museum in Neuchâtel, the specimen is not in their collections. The specimen was already in a bad state when F.-J. Pictet described it. It is now presumably lost.

Palingenia puella F.-J. Pictet, 1843

Palingenia puella F.-J. Pictet, 1843-1845: 145, pl. 11, fig. 4.
Campsurus puella. – Eaton, 1871: 58 (transfer).
Polymitarcys albus Say, 1824. – Eaton, 1883: 47 (erroneous synonymization).
Tortopus puella. – McCafferty, 1996: 3 (transfer).
Tortopsis puella. – Molineri, 2010: 27 (transfer).

Accepted name: *Tortopsis puella* (F.-J. Pictet, 1843).

Locus typicus: "Cette espèce provient de la Nouvelle Orléans…" [Louisiana, USA].

Type material: Holotype [by monotypy], female imago. Not in MHNG, not traced.

Remarks: F.-J. Pictet mentioned that he had seen an incomplete female coming from the National Museum of Natural History (MNHN) in Paris. Attempts made by Jean Legrand, former curator of small insect orders at the MNHN, and by the first author to locate the specimen failed. It is presumably lost.

Palingenia indica F.-J. Pictet, 1843

Palingenia indica F.-J. Pictet, 1843-1845: 151-152, pl. 13, fig. 4.
Polymitarcys indicus. – Eaton, 1871: 61 (transfer).
Polymitarcys australis Hagen, 1888. – Ulmer, 1924b: 32 (tentative synonymization).
Ephoron indicus. – Spieth, 1940: 110 (transfer).

Accepted name: *Ephoron indicus* (F.-J. Pictet, 1843).

Locus typicus: "… qui provenait des Indes Orientales".

Type material: NMW; holotype [by monotypy], ♀ imago; Pictet vidit / *Polymitarcys indicus* Pict. Type [Ulmer's handwriting].

Remarks: The specimen, sent by Kollar, is slightly damaged (distal half of right fore wing, right middle leg, left hind leg and right cercus missing). Most probably it was collected by Carl August v. Hügel (1759-1870), who travelled in southern India and Punjab in 1831-1836. His material was acquired in 1839.
The most complete description of this species was provided by Chopra (1928) based on new material from India. Moreover, he had the opportunity to examine the holotype deposited in Vienna. His material has in common with the type: (i) the costal field of the forewing tinted with violet, (ii) a longitudinal violet band dorsally on the abdomen, (iii) the coloration of the fore legs of the female. It differs, however, by the number of intercalaries in the cubital field (4-5 on the type specimen but 6 in the Indian material) and by the length of the terminal filament, equal in length to the cerci according to F.-J. Pictet's description and drawing. In the type specimen the right cercus is broken near the base (remainder missing), the left cercus and the terminal filament are apparently of equal length, but in fact the tip of the left cercus is missing and the correct measurements presumably correspond with Chopra's material. The paracercus is obviously shorter in the Indian material ("in the female the lateral ones are 11-13, while the median seta is 7-8 mm long"; Chopra, 1928: 128). According to Lestage (1921) the single female from Tonkin (Vietnam) and referred to *E. indicus* possessed a terminal filament as long as its cerci.
Ulmer (1913) reported several females of *E. indicus* from Java. According to his short description, the terminal filament is shorter and the cubital field of the fore wing is slightly different to what Lestage observed in his Vietnamese specimens.

Palingenia savignyi F.-J. Pictet, 1843

Fig. 3

Ephemera sp. – Savigny, 1817: 194, pl. 2, fig. 5.
Palingenia Savignyi F.-J. Pictet, 1843-1845: 157.
Polymitarcys Savignii [sic]. – Eaton, 1871: 61 (transfer).
Polymitarcys Savignyi. – Eaton, 1883: 46.
Ephoron savigni [sic]. – Oliff, 1960: 339 (transfer).

Accepted name: *Ephoron savignyi* (F.-J. Pictet, 1843).

Locus typicus: "Haute Egypte".

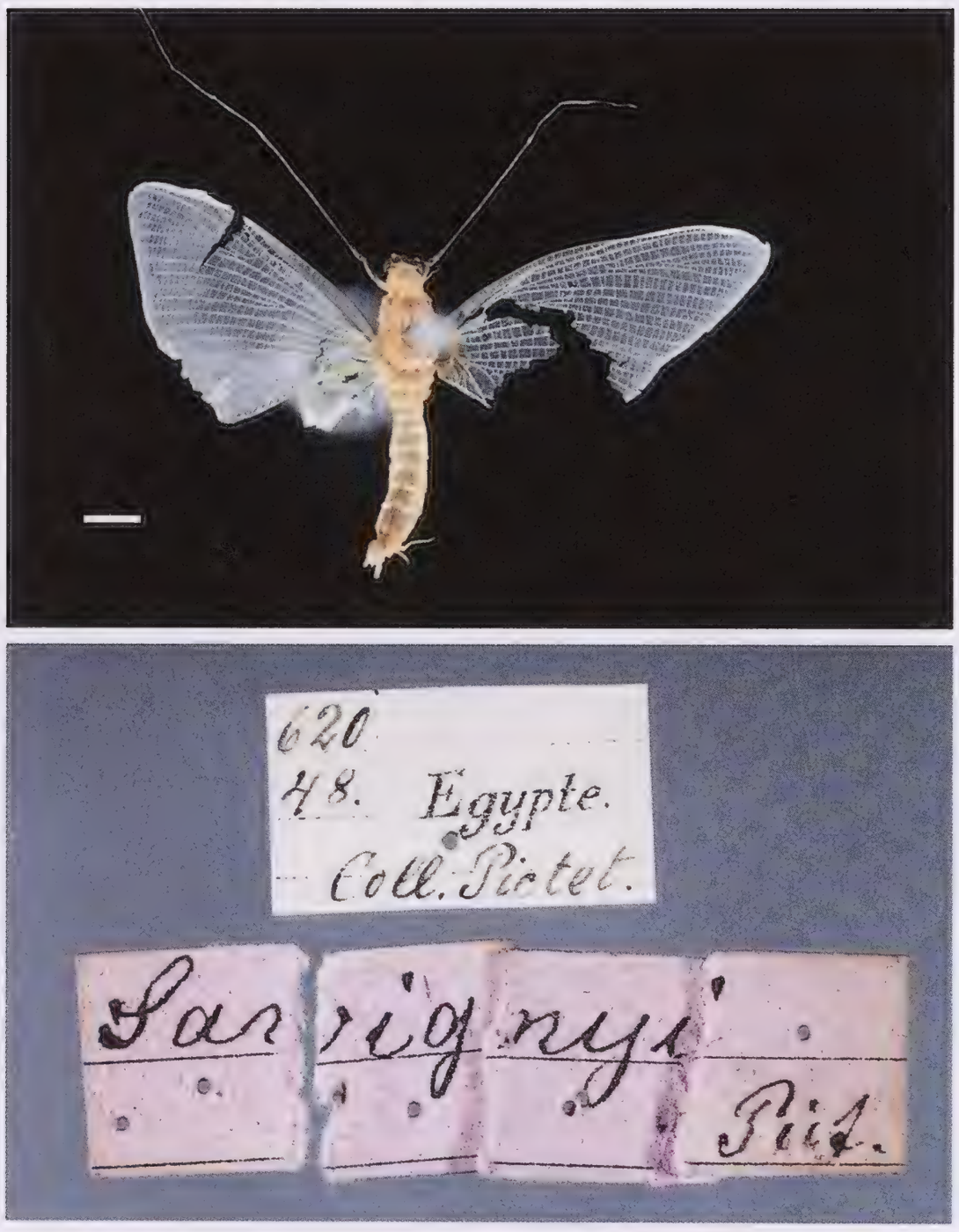


Fig. 3. *Ephoron savignyi* (F.-J. Pictet, 1843), male imago and labels. Scale bar: 2 mm.

Type material: Holotype [by monotypy] female subimago, not traced.

Remarks: F.-J. Pictet briefly mentioned this species in the addenda of the genus *Palingenia*, saying he had not seen any specimens and based his diagnosis on the drawing provided by Savigny (of a female subimago), in accordance with article 12.2.7 of the International Code on Zoological Nomenclature (International Commission of Zoological Nomenclature, 1999). However, Eaton (1871) mentioned that several specimens were kept in F.-J. Pictet's collection, and that later F.-J. Pictet gave him a specimen (Eaton, 1883). In the MHNG two specimens are still present: a male imago (Fig. 3), 620 48 Egypte coll. Pictet / Savignyi Pict. [purple label broken in four pieces], and a male imago, 620 48 Egypte coll. Pictet / M. De Selys Longchamp. None of them can be considered as type material. The type material should be in Savigny's collection in the National Museum of Natural History in Paris, but a recent visit by the first author failed to find it. However, this is of no consequence for the validity of the species name (see International Commission on Zoological Nomenclature, 1999: article 73.1.4).

Baetis fluminum F.-J. Pictet, 1843

Baetis fluminum F.-J. Pictet, 1843-1845: 164-166, pl. 16-19.
Heptagenia fluminum. – Eaton, 1871: 146 (transfer).
Ecdyurus fluminum. – Eaton, 1888: 289 (transfer).
Ecdyonurus fluminum. – Ulmer, 1920b: 136 (transfer).
Ecdyonurus dispar (Curtis, 1834). – Thomas, 1968b: 52 (synonymization).

Accepted name: *Ecdyonurus* (*Ecdyonurus*) *dispar* (Curtis, 1834).

Locus typicus: "… le Rhône, tant dans les environs de Genève qu'à l'autre extrémité du lac".

Type material: Syntypes (male and female imagines and subimagines), not traced. No original material of *B. fluminum* remains in the MHNG.

Remarks: Eaton (1871) already mentioned that only subimagines were present in the collection, but none could be found during our study. The status of this species was enigmatic for a long time until Thomas (1968b) clarified it and suggested that the concept of *E. fluminum* had been applied differently among the mayfly taxonomists of the first half of the 20th century. Thomas (1968b) convincingly demonstrated that F.-J. Pictet's concept of *E. fluminum* corresponds to that of *E. dispar* Curtis, 1834.

Baetis forcipula F.-J. Pictet, 1843

Baetis forcipula F.-J. Pictet, 1843-1845: 170.
Heptagenia forcipula. – Eaton, 1871: 152 (transfer).
Ecdyurus forcipula. – Eaton, 1888: 286 (transfer).
Ecdyonurus forcipula. – Ulmer, 1920b: 136 (transfer).
Ecdyonurus (*Ecdyonurus*) *venosus* (Fabricius, 1775: 304). **new synonym**

Accepted name: *Ecdyonurus* (*Ecdyonurus*) *venosus* (Fabricius, 1775).

Locus typicus: "… la plus grande partie de l'Allemagne, … Autriche, Bohème et de Bavière… Piémont".

Type material: NMW; syntype, ♂ imago; Reichenau, Koll[ar] / *Ecdyonurus forcipula* Pict. [Ulmer's handwriting] / Genitalia in glycerin in microvial. – NMW; syntype, ♂ imago; Reichenau, Koll[ar.] / Genitalia in glycerin in microvial, right fore leg missing. – NMW; syntype, ♂ imago; Aust[ria], Kollr. [= Kollar].

Remarks: F.-J. Pictet proposed the new taxon with reservations in a note (F.-J. Pictet, 1843: 169): "Il y a probablement une nouvelle espèce... Si c'est bien une espèce distincte, elle devra porter le nom de *B. forcipula*, nom sous lequel elle m'a été communiquée par M. Kollar". As the description of F.-J. Pictet was expressly based on material (and/or manuscript notes) provided by Kollar from Austria, those specimens are syntypes (International Commission on Zoological Nomenclature, 1999: article 73.2.1). While proposed

only conditionally by F.-J. Pictet, the name is clearly available under article 11.5.1. Although Ulmer (1921: 241) stated "Typen dieser Art finde ich nicht" [I cannot find types of this species], he nevertheless mentioned two of the above listed syntype specimens, which he (correctly) identified as *Ecdyonurus venosus*. Among the specimens present in the NMW collection and placed under the species name *E. forcipula,* three pinned specimens were without doubt collected by Kollar and bear his handwritten label. Considering all the circumstantial evidence, these specimens must be considered as part of the type series (syntypes) although they bear no direct reference to F.-J. Pictet.

The concept of *E. forcipula* has been interpreted differently among taxonomists in the past (e.g., Meyer-Dür, 1874: 314; Eaton, 1887: 286; Rostock, 1888: 154; Ulmer, 1929: 32; Schönemund, 1930: 23; Kimmins, 1942a: 123; Kimmins, 1942b: 504) and redescriptions have almost certainly been based on material that belongs to several taxa. Bauernfeind (1990: 76) stated that Kollar's specimens belong to *Ecdyonurus venosus* but did not propose a formal synonym. In the meantime a neotype for *Ecdyonurus venosus* was proposed (Bauernfeind & Haybach, 2012) and subsequently fixed (International Commission on Zoological Nomenclature, 2015) which enables us to formally place *Baetis forcipula* F.-J. Pictet, 1843 (currently in *Ecdyonurus*) in the synonymy of *Ephemera venosa* Fabricius, 1775 (currently in *Ecdyonurus*). The thorough description of *Ecdyonurus forcipula* by Thomas (1968b: 61) denotes a taxon new to science, for which the name *Ecdyonurus* (*Ecdyonurus*) *alaini* sp. nov. is proposed in honour of our friend Alain Thomas and his outstanding work on Ephemeroptera.

Ecdyonurus (*Ecdyonurus*) *alaini* Bauernfeind, sp. nov.

Fig. 4

Ecdyonurus forcipula. – Thomas, 1968b: 61. [misidentification, nec *Ecdyonurus forcipula* (F.-J. Pictet, 1843)]

Type material: NMW; holotype, ♂ imago [reared], with legs, wings and genitalia on microscope slide and accompanied by its nymphal skin (in parts on slide); Neste d'Aure, app. 42°48'N 0°6'E, Massif de Néouvielle, 1600 m a.s.l., Hautes-Pyrénées, France; 10.7.1965; leg. A. Thomas. – NMW; paratype, 1 ♂ imago [reared], accompanied by its nymphal skin; same data as for holotype. – NMW; paratype, 1 ♂ imago [reared], accompanied by its nymphal skin; Aure Valley, 1200 m a.s.l., Hautes-Pyrénées, France; 30.7.1965; leg. A. Thomas.

Diagnosis: The new taxon is characterized by the following combination of characters: Imagines usually slightly smaller than those of *E. venosus* (fore wing length of holotype 14.0 mm), overall abdominal colouration more sombre, dull yellowish brown (in *E. venosus* more reddish), laterally a rather indistinct triangular brownish blotch in posterior half of abdominal segments 2-8 (frequently missing; a distinct triangular dark red to violet-black blotch in posterior half of abdominal segments in *E. venosus*), posterior margin of forceps base almost straight (distinctly convex in *E. venosus*) with (rarely without) low, broad and rounded lateral teeth. Penis lobes (Fig. 4A) slightly more massive, basal sclerite more broadly triangular, with few or no teeth along posterior margin (basal sclerite narrowly triangular, with strong teeth along posterior margin in *E. venosus*), median titillators with a longitudinal row of inconspicuous subapical teeth or smooth (median titillators with a longitudinal row of strong subapical teeth in *E. venosus*). Last instar larvae are characterized by rather strong, almost straight, apically broadly rounded pronotal processes (Fig. 4B) (apically bluntly pointed in *E. venosus*) and comparatively weak and short lateral processes (Fig. 4C) (1/5 of segment length) on abdominal sterna 2-9 (strong and long, 1/3 of segment length in *E. venosus*).

Baetis cyanops F.-J. Pictet, 1843

Baetis cyanops F.-J. Pictet, 1843-1845: 171-172, pl. 20, fig. 2.
Heptagenia elegans (Curtis, 1834). – Eaton, 1871: 145 (synonymization).
Heptagenia sulphurea (Müller, 1776). – Eaton, 1888: 268 (synonymization).

Accepted name: *Heptagenia sulphurea* (Müller, 1776).

Locus typicus: "… au bord du Rhône ... " [Geneva].

Type material: Syntypes (male imagines?), not traced.

Remarks: A well-established synonymy. *Heptagenia sulphurea* is still present in the Rhone River at Geneva (Sartori *et al.,* 1989).

Baetis montana F.-J. Pictet, 1843

Baetis montana F.-J. Pictet, 1843-1845: 172-173, pl. 20, fig. 3.
Heptagenia montana. – Eaton, 1871: 154 (transfer).
Heptagenia montana. – Eaton, 1888: 302 (species of uncertain generic placement).

Accepted name: *Baetis montana* F.-J. Pictet, 1843 **nom. dub.**

Locus typicus: "… petit ruisseau qui descend du Brévent au-dessus de Chamounix".

Type material: Holotype [by monotypy], male imago?, not in MHNG.

Remarks: F.-J. Pictet gave a very brief description of this alpine species. Eaton (1888) was unable to place it with certainty among the Heptageniidae. No original

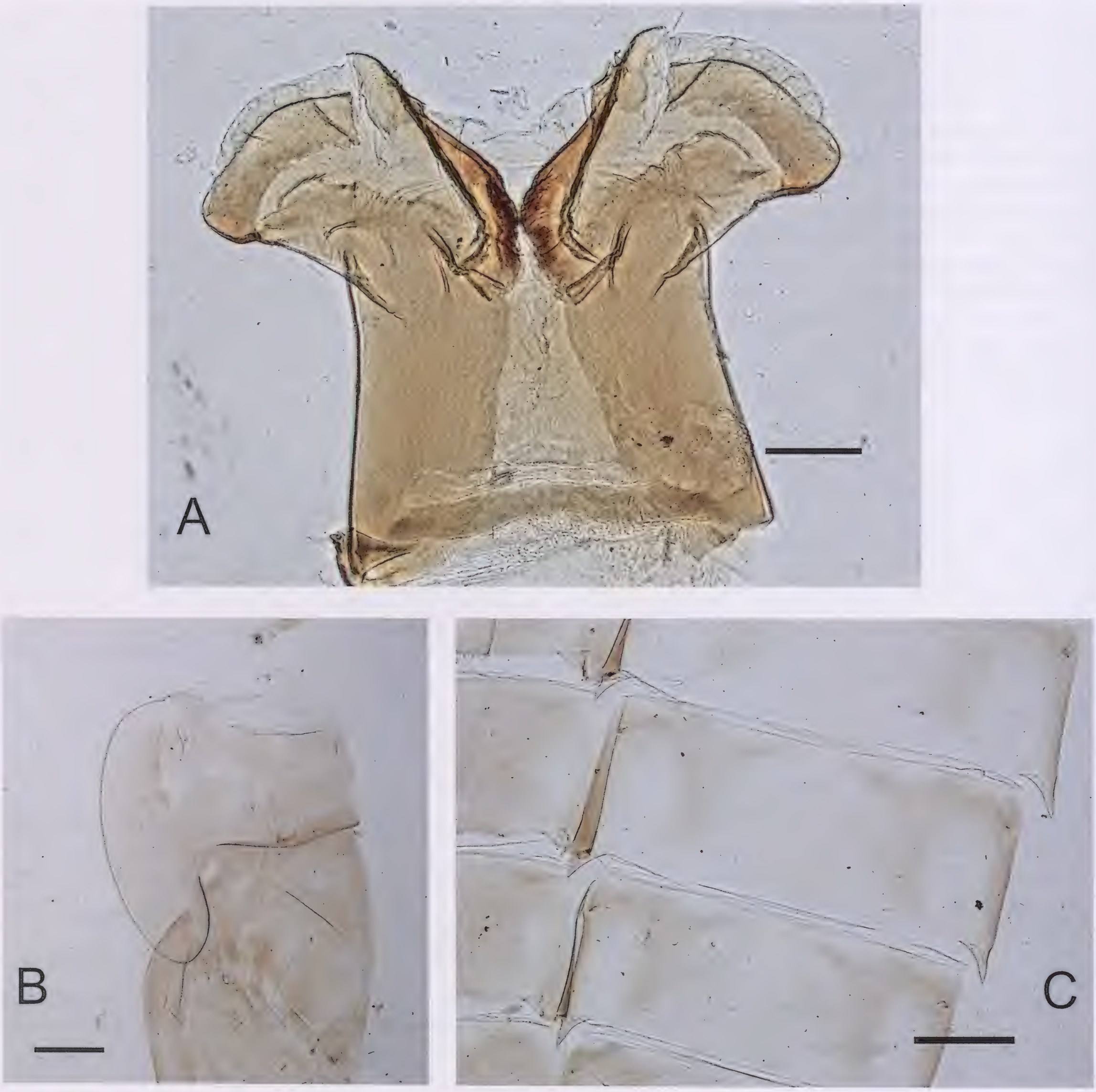


Fig. 4. *Ecdyonurus* (*Ecdyonurus*) *alaini* sp. nov. (A) Penis of holotype (dorsal view, slide preparation). Scale bar 0.2 mm. (B) Left half of pronotum (last larval instar exuvia of holotype; slide preparation). Scale bar 0.5 mm. (C) Abdominal sterna 4-6 (last larval instar exuvia of holotype; slide preparation). Scale bar 0.5 mm. Photos by Mag. H. Bruckner.

material of this taxon could be traced. In the MHNG there is one female imago with the following label data "620 Burgdorf 48 coll. Pictet / Baetis montana P. Bgdf 9 Juni", obviously a specimen collected and identified by Meyer-Dür and most probably belonging to the so called *Ecdyonurus helveticus* species-group. The name *Baetis montana* F.-J. Pictet, 1843 should be considered a *nomen dubium* (see also Haybach, 2010).

***Baetis purpurascens* F.-J. Pictet, 1843**

Baetis purpurascens F.-J. Pictet, 1843-1845: 174-175, pl. 20, fig. 4.

Heptagenia venosa (Fabricius, 1775). – Eaton, 1871: 151 (synonymization).

Ecdyurus venosus (Fabricius, 1775). – Eaton, 1888: 302 (transfer).

Ecdyonurus venosus (Fabricius, 1775). – Ulmer, 1920b: 136 (transfer).

Accepted name: *Ecdyonurus* (*Ecdyonurus*) *venosus* (Fabricius, 1775).

Locus typicus: "… au bord de la petite rivière de Viaison derrière le mont Salève".

Type material: Holotype [by monotypy], female imago, not in MHNG.

Remarks: The description was obviously based on a single female and the taxon was considered by F.-J. Pictet to be closely related and very similar to *Baetis venosa* Fabricius, 1775, except for some differences in colouration. No material could be traced and the name *Baetis purpurascens* F.-J. Pictet can be considered a well-established junior synonym of *Ecdyonurus venosus*, a species widespread in Europe.

Baetis semitincta F.-J. Pictet, 1843

Baetis semitincta F.-J. Pictet, 1843-1845: 180-181, pl. 22, figs 1-3.
Heptagenia semicolorata (Curtis, 1834). – Eaton, 1871: 136 (synonymization with doubt).
Rhithrogena semicolorata (Curtis, 1834). – Eaton, 1888: 256 (transfer).
Rhithrogena semitincta. – Kimmins, 1936: 279 (revalidation of species name).
Rhithrogena semicolorata (Curtis, 1834). – Sowa, 1971: 897 (synonymization).

Accepted name: *Rhithrogena semicolorata* (Curtis, 1834).

Locus typicus: "…sur les bords de la petite rivière qui se jette à Versoix dans le lac de Genève".

Type material: MHNG; 3 syntypes (♂ and ♀ imagines, ♂ subimago).

Remarks: The two male specimens (considered by Sowa as part of the original type series) are pinned on the same needle, and the lower one has been designated as lectotype by Sowa (1971: 897). It bears the following labels: 620 Genthod 48 Genève coll. Pictet / Baetis semitincta [in Sowa's opinion probably F.-J. Pictet's handwriting] / Rhithrogena semitincta (Pictet), lectotype [= semicolorata (Curtis)] Det. R. Sowa.
This taxon has been controversial for a long time. Eaton (1888) mentioned several variants in the coloration of the wings, which he did not consider of taxonomic value. Kimmins (1936) proved that the concept of *R. semicolorata* sensu Eaton (1888) fits at least two species and he re-established *R. semitincta* as a valid name. Finally, Sowa (1971) studied the type series, proposed *R. semitincta* (F.-J. Pictet, 1843) as a junior subjective synonym of *R. semicolorata* (Curtis, 1834) and described *R. semitincta* sensu Kimmins (1936) nec *R. semitincta* (F.-J. Pictet, 1843) as a new species, *R. picteti* Sowa, 1971.

Baetis cerea F.-J. Pictet, 1843

Baetis cerea F.-J. Pictet, 1843-1845: 183-184, pl. 23, fig. 2.
Heptagenia flavipennis (Dufour, 1841). – Eaton, 1888: 273 (synonymization).
Heptagenia longicauda (Stephens, 1836). – Kimmins, 1942a: 122 (synonymization).

Accepted name: *Heptagenia longicauda* (Stephens, 1836).

Locus typicus: "… sur les bords du lac de Genève…".

Type material: Holotype [by monotypy], male imago, not traced.

Remarks: In the absence of any specimen of this species in the MHNG, we follow the synonymy proposed by Kimmins (1942a). F.-J. Pictet (1843: 193) already noticed that *B. longicauda* Stephens, 1836 was closely related to his *B. cerea*.
Heptagenia longicauda is extremely rare in Switzerland, the last record from the lake of Geneva area is more than 30 years old (Sartori & Dethier, 1985).

Baetis flaveola F.-J. Pictet, 1843

Fig. 5

Baetis flaveola F.-J. Pictet, 1843-1845: 186-187, pl. 23, fig. 4.
Heptagenia flaveola. – Eaton, 1871: 136 (transfer).
Ecdyurus verticis (Say, 1839). – Eaton, 1888: 256 (synonymy).
Heptagenia interpunctata (Say, 1839). – Ulmer, 1921: 242 (synonymization).
Stenonema flaveolum. – McCafferty & Bae, 1992: 169 (transfer and considered a *nomen dubium*).

Accepted name: *Baetis flaveola* F.-J. Pictet, 1843 **nom. dub**.

Locus typicus: "… Amérique septentrionale…".

Remarks: F.-J. Pictet (1843: 187) mentioned only one female specimen from the NMW sent by Kollar ("L'exemplaire qui a servi a cette description... "), and provided only one illustration (F.-J. Pictet, 1843: pl. 23, fig. 4). There is a heavily damaged specimen in the NMW, which corresponds well with Pictet's written description (but not with the illustration in fig. 4). As already pointed out by Ulmer (1921), another specimen has obviously been illustrated on plate 23, fig. 4 of the original publication.

Type material: NMW; ♀ subimago [syntype ?] (Fig. 5A); Pöp[pig] 852 / Pictet vidit / *Baetis flaveola* Pict. [Hermann Hagen's handwriting] / *Heptagenia interpunctata* Say [Ulmer's handwriting] / coll. Nat. Mus. Wien / (Fig. 5B). Heavily damaged (head, left wings, left middle leg, right middle and hind leg missing, right wings partly missing and glued to thorax, end of abdomen damaged and cerci missing). – NMW; ♂ subimago [syntype ?] (Fig. 5C); Par[reyss]. c. 17. 196. / Pictet vidit / *Heptagenia pulchella* Walsh (?) [Ulmer's

Fig. 5. *Baetis flaveola* F.-J. Pictet, 1843 **nom. dub.** (A) Syntype [?]. (B) Labels of syntype [?] 1. Scale bar: 5 mm. (C) Syntype [?] 2. Scale bar: 5 mm. (D) Labels of syntype [?] 2. Scale bar: 5 mm.

handwriting] / coll.Nat.Mus.Wien (Fig. 5D). Slightly damaged (left fore leg, basal half of left hind wing and right hind wing completely missing, distal part of cerci missing).

Remarks: Eduard Friedrich Poeppig (1797-1868) travelled in Cuba (1823-24) and Pennsylvania (1824-26). In 1826 he departed for Valparaiso and spent several years performing scientific explorations throughout Chile, Peru and Brazil during 1827-1832. Material from his travels was acquired by the NMW in 1840. In later years he also sold specimens from different sources (Cuba 1843, Port Natal 1845, etc.). Ludwig Parreyss (1796-1879) was an established natural history dealer (mostly in insects and birds) in Vienna and material has been very frequently acquired from him by the NMW.

McCafferty & Bae (1992: 70) in their discussion confused part of the labels and erroneously reported Hagen's label as being with the male subimago. None of the specimens, however, can be identified with any degree of certainty and McCafferty & Bae's decision to consider the name *Baetis flaveola* F.-J. Pictet, 1843 as a *nomen dubium* should be followed.

Baetis guttata F.-J. Pictet, 1843

Baetis guttata F.-J. Pictet, 1843-1845: 187-188, pl. 24, fig. 3.
Heptagenia guttata. – Eaton, 1871: 156 (transfer).
Ecdyurus guttatus. – Eaton, 1888: 301 (transfer).
Ecdyonurus guttatus. – Ulmer, 1920b: 136 (transfer).
? Siphlonella guttata. – Flowers & Peters, 1981: 153 (transfer).
Siphlonella guttata. – Domínguez *et al.*, 2006: 556 (*nomen dubium*).

Accepted name: *Baetis guttata* F.-J. Pictet, 1843 **nom. dub.**

Locus typicus: "Chili".

Type material: Holotype [by monotypy] female imago, not traced.

Remarks: F.-J. Pictet examined a single female from the National Museum of Natural History in Paris. This species certainly does not belong to the genus *Ecdyonurus* nor to the family Heptageniidae, which is absent from South America. The combination with *Siphlonella* (Oniscigastridae) proposed by Flowers & Peters (1981) is mainly based on the colour pattern. The holotype is presumably lost and the name *Baetis guttata* should be considered a *nomen dubium*.

Baetis australasica F.-J. Pictet, 1843

Baetis australasica F.-J. Pictet, 1843-1845: 189-190, pl. 24, fig. 1.
Leptophlebia australasica. – Eaton, 1871: 78 (transfer).
Atalophlebia australasica. – Eaton, 1888: 86 (transfer).
Atalophlebia costalis (Burmeister, 1839). – Ulmer, 1920b: 115 (synonymization).
Atalophlebia australasica. – Harker, 1954: 248 (*Baetis costalis* Burmeister, 1839 is a *nomen praeoccupatum*).

Accepted name: *Atalophlebia australasica* (F.-J. Pictet, 1843).

Locus typicus: "…Nouvelle-Hollande" [New South Wales, Australia].

Type material: NMW; holotype [by monotypy], ♂ imago; Pictet vidit / Atalophlebia costalis Burm. (australasica Pict.) [Ulmer's handwriting].

Remarks: F.-J. Pictet mentioned "Les deux exemplaires figurés …" and described the male imago and [female] subimago, attributing the latter only doubtfully (F.-J. Pictet, 1843: 189 "Id.? Pseudimago, Planche XXIV, FIG. 2"; F.-J. Pictet, 1845: 10 "Probablement le mâle [sic] subimago ... "). According to the International Commission on Zoological Nomenclature (1999: article 72.4.1), the male specimen is therefore the holotype by monotypy.
Kollar probably had sent three specimens to F.-J. Pictet: a male (listed above), a female subimago (Lotz. 12 [= Johann Lhotsky, who collected in New South Wales in 1832-1838] / australasica subimago), and a female (Pictet vidit / Lotz. 11).
Ulmer (1921: 243) listed "drei Typen [three types]" but obviously confused one label. The remark "Sidney" [probably in F.M. Brauer's handwriting] refers to an additional male specimen which was collected during the Novara Expedition in November 1858 but was not examined by F.-J. Pictet.
Ulmer (1920b) synonymized *B. australasica* F.-J. Pictet, 1843 with *B. costalis* Burmeister, 1839, but Harker (1954) recognized that *Baetis costalis* Burmeister, 1839 is a homonym of *B. costalis* Curtis, 1834 and so she reinstalled the older synonym as the valid name of the species.

Potamanthus ferreri F.-J. Pictet, 1843

Potamanthus Ferreri F.-J. Pictet, 1843-1845: 203-204, pl. 25, fig. 1.
Potamanthus luteus (Linné, 1767). – Bae & McCafferty, 1991: 53 (synonymization).

Accepted name: *Potamanthus luteus* (Linné, 1767).

Locus typicus: "… aux environs de Turin..." [Italy].

Type material: Holotype [by monotypy], male imago, not traced.

Remarks: Eaton (1884) already noticed that the type was missing in F.-J. Pictet's collection in 1867. The synonymy proposed by Bae & McCafferty (1991) is consistent with the fact that *P. luteus* is the only *Potamanthus* species found throughout Europe.

Potamanthus geerii F.-J. Pictet, 1843

Potamanthus Geerii F.-J. Pictet, 1843-1845: 211-214, pl. 26, figs 1-3.
Leptophlebia helvipes (Stephens, 1836). – Eaton, 1871: 85 (transfer and synonymization).
Leptophlebia submarginata (Stephens, 1836). – Eaton, 1884: 94 (synonymization).
Paraleptophlebia submarginata (Stephens, 1836). – Lestage, 1917: 344 (transfer).

Accepted name: *Paraleptophlebia submarginata* (Stephens, 1836).

Locus typicus: "J'en possède des exemplaires de l'Italie septentrionale, ... elle n'est pas rare aux environs de Genève…".

Type material: Syntypes (male and female imagines, female subimago, larva), not traced.

Remarks: In the MHNG there is a series of *Leptophlebia submarginata*; 3 specimens (1 male, 2 females) among them bear the label "*Potamanthus geerii* L.", but they originate from Burgdorf (ex. coll. Meyer-Dür) and have obviously been collected after the publication of the original description.
Note the obvious printing error in the original description (F.-J. Pictet, 1843: 211), attributing this species to Lin[naeus] instead of declaring it a new species.

Potamanthus castaneus F.-J. Pictet, 1843

Potamanthus castaneus F.-J. Pictet, 1843-1845: 215-216, pl. 26, figs 4-5.
Leptophlebia castanea. – Eaton, 1871: 86 (transfer).
Paraleptophlebia castanea. – Ulmer, 1920: 116 (transfer).
Paraleptophlebia submarginata (Stephens, 1836). – Puthz, 1978: 262 (synonymization).

Accepted name: *Paraleptophlebia submarginata* (Stephens, 1836).

Locus typicus: "... au bord d'un ruisseau d'eau vive, à l'extrémité du lac de Genève, près des marais de Villeneuve…".

Type material: Syntypes (male and female imagines, male subimago), not traced.

Remarks: As already mentioned by Puthz (1978), material housed in the MHNG consists of 10 subimagines, none of them originating from the type locality or its surroundings. Description and drawings of the subimaginal wing pattern correspond well with *P. submarginata*.

Potamanthus brunneus F.-J. Pictet, 1843

Potamanthus brunneus F.-J. Pictet, 1843-1845: 217-219, pl. 27.
Leptophlebia fusca (Curtis, 1834). – Eaton, 1871: 90 (transfer and synonymization).
Habrophlebia fusca (Curtis, 1834). – Eaton, 1884: 116 (transfer).

Accepted name: *Habrophlebia fusca* (Curtis, 1834).

Locus typicus: "… dans des ruisseaux qui prennent leur source au pied du mont Salève".

Type material: Syntypes (male and female imagines, male subimago, larva), not traced.

Remarks: In the MHNG five non-type specimens are present under the name *H. fusca*. One bears the label "*Potamanth. brunneus* Pict." representing in fact a male imago of *Serratella ignita* (Ephemerellidae). Among the four others, three also belong to *S. ignita* and the last one probably to *H. fusca*, with a label "Rch 19.5" (for May 19 ?).

Potamanthus gibbus F.-J. Pictet, 1843

Potamanthus gibbus F.-J. Pictet, 1843-1845: 226-228, pl. 31-32.
Ephemerella gibba. – Eaton, 1871: 99 (transfer).
Ephemerella ignita (Poda, 1761). – Eaton, 1884: 126 (synonymization).
Serratella ignita (Poda, 1761). – Jacob, 1993: 107 (transfer).

Accepted name: *Serratella ignita* (Poda, 1761).

Locus typicus: "… sur les bords d'un petit ruisseau d'eau vive près de Villeneuve, à l'extrémité du lac de Genève".

Type material: Syntypes (male and female imagines and subimagines), not traced.

Remarks: In the MHNG no specimens remain from the type locality and/or bear an original identification. Some of them are labelled "*Ephemerella ignita* Poda Eaton determ[inavit]". *Serratella ignita* is a species widespread and common throughout Europe that exhibits various colour patterns, from green to red.

Potamanthus aeneus F.-J. Pictet, 1843

Potamanthus aeneus F.-J. Pictet,1843-1845: 229-231, pl. 33.
Ephemerella aenea. – Eaton, 1871: 99 (transfer).
Ephemerella ignita (Poda, 1761). – Eaton, 1884: 126 (synonymization).
Serratella ignita (Poda, 1761). – Jacob, 1993: 107 (transfer).

Accepted name: *Serratella ignita* (Poda, 1761).

Locus typicus: "… un ruisseau qui prend sa source au pied du mont Salève".

Type material: Syntypes (male and female imagines and subimagines, larva), not traced. No relevant material in the MNHG.

Potamanthus inanis F.-J. Pictet, 1843

Fig. 6

Potamanthus inanis F.-J. Pictet, 1843-1845: 232-234, pl. 24, fig. 4.
Potamanthus (?) *inanis.* – Eaton, 1888: 296 (*incertae sedis*).
Leptohyphodes inanis. – Ulmer, 1920a: 50-51 (transfer). – Domínguez *et al.*, 2006: 279.

Accepted name: *Leptohyphodes inanis* (F.-J. Pictet, 1843).

Locus typicus: "… elle provient du Brésil" [Rio de Janeiro].

Type material: NMW; 7 syntypes (Fig. 6A): 6 ♂ imagines, Shtt.[Schott] (blue label) / Pictet vidit; 1 ♂ imago, Shtt.[Schott] (blue label) / Pictet vidit / *Leptohyphodes* (Ulm.) *inanis* Pictet Typen [Ulmer's handwriting].

Remarks: Some specimens are more or less damaged but on the whole in comparatively good condition (Fig. 6B-C). Heinrich Wilhelm Schott collected in Rio de Janeiro during 1817-1821, where he was practically all the time restricted to the vicinity of the city (Schott, 1822). Two of his excursions reached Canta Gallo (= Cantagalo 21°58"S 42°22"W) and Macacú (22°42'S 43°02"W). Ulmer (1921: 244) listed "acht Typen" and provided a redescription of the material. It seems probable that Kollar sent just a sample of 2 specimens to F.-J. Pictet (he based his description on "... deux exemplaires secs"), and afterwards labelled the complete series. F.-J. Pictet, however, seems to have recognized this and according to the International Commission on Zoological Nomenclature (1999: article 72.4.1.1), the seven existing specimens constitute the type series. *Leptohyphodes inanis* is the type species of the genus *Leptohyphodes* Ulmer, 1920a and is so far only known from Brazil (Domínguez *et al.*, 2006).

Cloe rhodani F.-J. Pictet, 1843

Cloe rhodani Pictet, 1843-1845: 248-251, pl. 36-39.
Baetis rhodani. – Eaton, 1871: 114 (transfer).

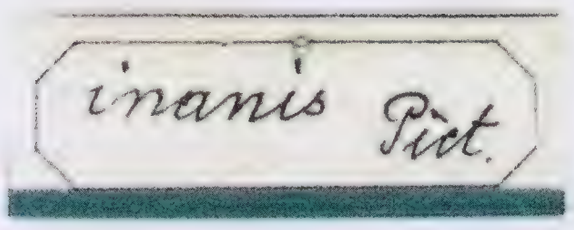
Accepted name: *Baetis rhodani* (Pictet, 1843).

Locus typicus: "… aux environs de Genève, dans le Rhône…".

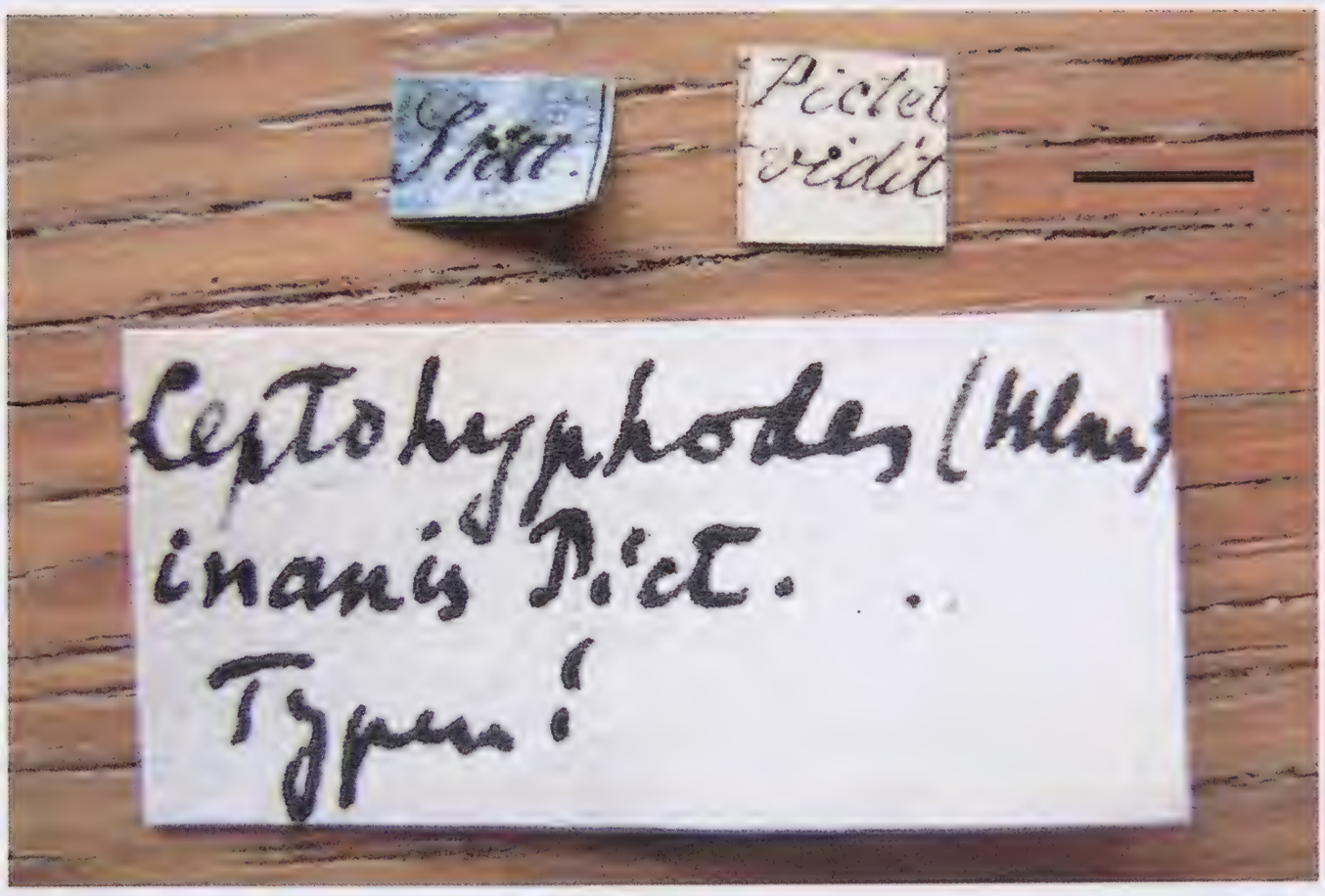
Type material: Syntypes (male and female imagines and subimagines, larvae), not traced and most probably lost.

Remarks: Most of the material still present in the MHNG came from Meyer-Dür and is labelled

A



B



C

Fig. 6. *Leptohyphodes inanis* (F.-J. Pictet, 1843). (A) Type series. Scale bar: 5 mm. (B) Syntype. Scale bar: 1 mm. (C) Labels of the type series. Scale bar: 5 mm.

"Burgdorf". *Baetis rhodani* is considered as one of the most abundant mayfly species in Europe. However, recent investigations indicate that it is a species complex (Bisconti *et al.*, 2016; Gattolliat *et al.*, 2015; Lucentini *et al.*, 2011; Rutschmann *et al.*, 2014; Williams *et al.*, 2006). Therefore Gattolliat & Sartori (2008) designated a neotype, which is deposited in the collection of the Museum of Zoology, Lausanne, with voucher specimens in the MHNG and the NMW.

Cloe translucida F.-J. Pictet, 1843

Cloe translucida F.-J. Pictet, 1843-1845: 255-256, pl. 40, figs 3-4.
Baetis luteolus (Müller, 1776). – Eaton, 1868: 88 (transfer and synonymization).
Centroptilum luteolum (Müller, 1776). – Eaton, 1871: 108 (transfer).

Accepted name: *Centroptilum luteolum* (Müller, 1776).

Locus typicus: "… sur les bords du lac de Genève… Des exemplaires venant d'Autriche m'ont été communiqués par M. Kollar, et la collection du chanoine Ferrero en renfermait un pris aux environs de Turin".

Type material: Syntypes (male and female imagines), not traced and most probably lost.

Remarks: Ulmer (1921: 246) already stated that he could not locate any specimens of *Cloe translucida* in the NMW collection.

Cloe alpina F.-J. Pictet, 1843

Cloe alpina F.-J. Pictet 1843-1845: 257-258, pl. 40, fig. 5.
Baetis alpinus. – Eaton, 1871: 118 (transfer).

Accepted name: *Baetis alpinus* (F.-J. Pictet, 1843).

Locus typicus: "… au bord d'un torrent très rapide, qui descend du mont Brévent dans la vallée de Chamounix".

Type material: Holotype [by monotypy], male imago, not traced. Müller-Liebenau (1969: 201) already mentioned that the type was probably missing.

Remarks: *Baetis alpinus* is a widespread species in montane and submontane zones of Europe. It is by far the most abundant species in the Alps.

Cloe melanonyx F.-J. Pictet, 1843

Cloe melanonyx F.-J. Pictet, 1843-1845: 258-259, pl. 40, fig. 6.
Baetis melanonyx. – Eaton, 1871: 118 (transfer).

Accepted name: *Baetis melanonyx* (F.-J. Pictet, 1843).

Locus typicus: "… dans la vallée d'Entremont (Faucigny)" [France].

Type material: Holotype [by monotypy?], male imago, not traced and most probably lost.

Remarks: Müller-Liebenau (1969: 201) designated a neotype in the collection of McLachlan deposited in the Natural History Museum of London, which was identified as *Baetis melanonyx* by Eaton and originates from Samoens in France.

Cloe litura F.-J. Pictet, 1843

Cloe litura F.-J. Pictet, 1843-1845: 258-259, pl. 41, figs 1-3.
Centroptilum lituratum. – Eaton, 1871: 109 (transfer).

Accepted name: *Cloe litura* F.-J. Pictet, 1843 **nom. dub**.

Locus typicus: "… au pied du mont Salève…".

Type material: Syntypes (male and female imago, male subimago), not traced and probably lost.

Remarks: In the MHNG eleven specimens are present under the name *Centroptilum lituratum*. All originate from Burgdorf (coll. Meyer-Dür) and cannot belong to the type series. All belong to the genus *Baetis* except for one female of *Centroptilum luteolum*. Seven are unidentifiable *Baetis* females, and three are males of *Baetis alpinus*. The taxon is only known from F.-J. Pictet's description and illustrations, and the name *Cloe litura* F.-J. Pictet should be considered a *nomen dubium*.

Cloe fasciata F.-J. Pictet, 1843

Cloe fasciata F.-J. Pictet, 1843-1845: 262-263, pl. 41, fig. 4.
Baetis fasciatus. – Eaton, 1871: 123 (transfer).
Callibaetis fasciatus. – Eaton, 1885: 197 (transfer).
Callibaetis (Abaetetuba) fasciatus. – Cruz *et al.*, 2017: 147 (transfer and designation as type species of the subgenus *Abaetetuba*).

Accepted name: *Callibaetis* (*Abaetetuba*) *fasciatus* (F.-J. Pictet, 1843)

Locus typicus: "… provient du Brésil" [Ipanema, Sao Paulo; 23°26'S 47°36'W].

Type material: NMW; holotype [by monotypy], ♀ imago; Natt[erer]: Brasi.: Ypanema / N[atterer]. c[ollectio]. Y[panema]. [on blue paper] / *Callibaetis fasciatus* Pict. [Ulmer's handwriting] / Pictet vidit.

Remarks: Damaged (most legs, left hind wing and right cercus missing). The holotype was already in bad condition when F.-J. Pictet described it. Ulmer (1921: 246) quoted the label incompletely (and probably misred "N.c.Y." for "No. 31") when he provided a complete redescription of the specimen and confirmed Eaton's (1885) assignment to the Panamerican genus *Callibaetis* Eaton, 1881. Johann Natterer collected in Brasil during 1817-1835 and stayed several times at Ipanema (1819-1822; see Vanzolini, 1993).

Cloe undata F.-J. Pictet, 1843

Cloe undata F.-J. Pictet, 1843-1845: 264-265, pl. 41, fig. 6.
Callibaetis undatus. – Eaton, 1885: 196 (transfer).

Accepted name: *Cloe undata* F.-J. Pictet, 1843 **nom. dub**.

Locus typicus: "… elle provient du Mexique".

Type material: Holotype [by monotypy], female imago, not traced and most probably lost.

Remarks: The specimen F.-J. Pictet examined was already in bad condition and was sent by Mr Coulon from Neuchâtel. The specimen is neither housed in the Natural History Museum of that town (J.P. Haenni in litt.) nor in the MHNG. The taxon is only known from F.-J. Pictet's description and illustration, and the name *Cloe undata* Pictet, 1843 should be considered a *nomen dubium*.

Caenis grisea F.-J. Pictet, 1843

Caenis grisea F.-J. Pictet, 1843-1845: 278-279, pl. 45, figs 1-2.
Caenis macrura (Stephens, 1836). – Eaton, 1871: 93 (synonymization). – Malzacher, 1986: 15.
Caenis halterata (Fabricius, 1777). – Eaton, 1885: 145 (synonymization).

Accepted name: *Caenis macrura* (Stephens, 1836).

Locus typicus: "… dans un petit marais situé au pied du mont Salève".

Type material: Syntypes (male imago and subimago), not traced and most probably lost.

Remarks: In the MHNG there is one specimen (female subimago) which bears the name *Caenis halterata* Fabr. and originates from Burgdorf (coll. Meyer-Dür). This specimen belongs to *Caenis luctuosa* (Burmeister, 1839). Without any new available data, we accept the synonymy proposed by Eaton (1871) and followed by Malzacher (1986), but in our opinion *C. grisea* could also be considered a junior subjective synonym of *C. luctuosa* (Burmeister, 1839).

Caenis argentata F.-J. Pictet, 1843

Caenis argentata F.-J. Pictet, 1843-1845: 279-280, pl. 43, fig. 6. – Kluge, 2020 (*nomen dubium*).
Caenis halterata (Fabricius, 1777). – Ulmer, 1921: 248 (synonymization).

Accepted name: *Caenis argentata* F.-J. Pictet, 1843 **nom.dub**.

Locus typicus: "… se trouve en Sicile".

Type material: NMW; holotype [by monotypy], female subimago.

Remarks: F.-J. Pictet wrote "Je ne connais que la femelle subimago de cette espèce… elle m'a été communiquée par le musée de Vienne". It is, however, rather doubtful whether the specimen in the NMW actually represents the type specimen: female subimago / *Caenis argentata* ? Kollar *lactea* Hffm. [Kollar's handwriting] / *Caenis horaria* (L.) det. Malzacher 1983 [no collector's label, no locality]. Ulmer (1921: 248) erroneously quoted three male subimagines in the NMW carrying F.-J. Pictet's label: "... davon stammen zwei aus Sizilien, eins aus Ischl.". None of these specimens actually bears F.-J. Pictet's label nor could they have represented type material, and most probably Ulmer's remark was based on a confusion with later acquisitions from Sicily not seen by F.-J. Pictet. Two additional male specimens and one female (in the NHW, all without labels) have been transferred to glycerin: "Caenis horaria (L.) sub nom. C. lactea (Pict.) det. Malzacher 6. 1983". None of them can be considered to represent type material.
Caenis horaria has so far not been recorded from Sicily and in our opinion it is most likely that Kollar incorrectly labelled a specimen of unknown origin at a later time. The specimen in question lacks the "Pictet vidit" label as well as any evidence concerning its origin, and it therefore seems justified to consider the name *Caenis argentata* F.-J. Pictet, 1843 as a *nomen dubium*.

Caenis varicauda F.-J. Pictet, 1843

Ephemera sp. – Savigny, 1817: 194, pl. 2, figs 6-7.
Caenis varicauda F.-J. Pictet, 1843-1845: 281-282, pl. 43, fig. 5.
Tricorythus varicauda. – Eaton, 1868: 82 (transfer).

Accepted name: *Tricorythus varicauda* (F.-J. Pictet, 1843).

Locus typicus: "… se trouve dans les partie supérieures de l'Egypte".

Type material: NMW; syntype, ♂ imago; KOTS 1 [= Kotschy leg.] / Pictet vidit / Typus [Ulmer's handwriting]. – NMW; syntype, ♂ imago; KOTS 2 / Pictet vid. – NMW; syntype, ♂ imago; KOTS 3 / Pictet vid.

Remarks: Theodor Kotschy (1813-1866) travelled the White and Blue Nile (Cairo to Torra, El Obeid, Torra, Karthum, Beni Shanqul) during 1836-1839. Material from this expedition was acquired by the NMW in 1839.

In his redescriptions Ulmer (1916: 14; 1921: 248) quoted "vier Typen [four types]" misreading the collector's acronym for "No. 21". The fourth specimen, however, does not represent type material and actually originates from a series collected by Josef Franz Natterer (1819-1862) in "Egypt" [Karthoum], acquired by the NMW in 1858 and not seen by F.-J. Pictet.
Beside this material, and as F.-J. Pictet mentioned "… et je la possède aussi dans ma collection", four specimens are located in the MHNG. They were found under the name *Caenis lactella* Eaton, 1884 (a synonym of

C. horaria) and all bear the same label: 620 48 Europe centr[ale] coll. Pictet. As no *Tricorythus* species has ever been reported from Europe, we can conclude that this is an example of the poor care the collection has suffered. These specimens fit the description given by F.-J. Pictet and may well constitute part of the original type series. This material is currently in ethanol.
Eaton (1868) based his genus *Tricorythus* on *Caenis varicauda* F.-J. Pictet, 1843 which was recently redescribed by Kluge (2010).

Caenis oophora F.-J. Pictet, 1843

Caenis oophora F.-J. Pictet, 1843-1845: 284-285, pl. 45, fig. 4.
Caenis macrura (Stephens, 1836). – Ulmer, 1921: 248 (synonymization).

Accepted name: *Caenis oophora* F.-J. Pictet, 1843 **nom. dub.**

Locus typicus: "… originaire de Sardaigne".

Type material: NMW; holotype [by monotypy], ♀ [subimago]; *Caenis macrura* Stephens, female subimago / Dhl. a. c. [= Dahl, alte collection ?] / Pictet vidit.

Remarks: The type specimen, denoted "femelle imago" by F.-J. Pictet, corresponds with his description and illustration. It had presumably been collected by Georg Dahl (1769-1832), naturalist and dealer in natural history specimens, who collected in Sardinia and whose respective material was acquired by the NMW in 1826. Ulmer (1921: 248) mentioned two female specimens with F.-J. Pictet's label, originating from Sardinia, but Pictet (1843) expressly mentionned that he examined only one specimen: "L'individu que j'ai eu à ma disposition...". The second specimen, with protruding eggs and labelled "Pictet vidit" (but without collector's label or locality) which corresponds with Ulmer's description, was doubtfully identified as "*C.* ? *luctuosa* (Burm.) det. Malzacher 1983". Another female specimen, labelled "C. oophora Pict. Sardinien (Mann) [probably Kollar's handwriting] / Pictet vidit" does not correspond with F.-J. Pictet's description and was probably subsequently identified by Kollar, but it had not been examined by F.-J. Pictet. It had either been obtained from or collected by Josef Johann Mann (1804-1889), who travelled Corsica in 1855 and Sicily in 1858 (Rogenhofer, 1889). In the light of this poor and contradictory evidence, the name *C. oophora* Pictet, 1843 is probably best considered a *nomen dubium*.

Oligoneuria anomala F.-J. Pictet, 1843

Oligoneuria anomala Pictet, 1843-1845: 291-292, pl. 47 figs 1-2.
Oligoneuria (*Oligoneuria*) *anomala.* – Salles *et al.*, 2014: 241.

Accepted name: *Oligoneuria anomala* F.-J. Pictet, 1843.

Locus typicus: "... venant du Brésil" [Rio de Janeiro district, Brasil].

Type material: NMW; one syntype (♀ subimago); Shtt [= Schott] [blue paper] / Pictet & Hagen vid. [remark: "& Hagen" obviously added later, probably by Hagen] / *Oligoneuria anomala* Kllr. Pict. Bras[ilien] Rio Janeiro [in Kollar's handwriting] / *Oligoneuria anomala* Pict. Type [Ulmer's handwriting]. Slightly damaged, hind wings crumpled and legs missing. – MHNG; one syntype (female subimago); not traced, probably lost.

Remarks: The original illustrations (F.-J. Pictet, 1845: pl. 46, figs 1-5) have obviously been drawn from the second syntype (femelle subimago, Pictet's specimen from an unknown locality [presumably Switzerland], "conservé dans alcool") which belongs to *Oligoneuriella rhenana* (Imhoff, 1852), as already stated by Hagen (1855: 270).
This taxon has been quite enigmatic for a long time although additional descriptions had been provided by Hagen (1855), Ulmer (1921), Needham & Murphy (1924) and Puthz (1973a). Domínguez *et al.* (2006) recently published supplementary information on the type material. A cladistics analysis by Salles *et al.* (2014) showed this species to be distinguishable by wing venation, but no other specimens are currently known.

MAYFLY TAXA DESCRIBED BY ALBERT-EDOUARD PICTET

Baetis flavida A.-E. Pictet, 1865

Baetis flavida A.-E. Pictet, 1865: 24, pl. 3, figs 1-6.
Siphlurus flavidus. – Eaton, 1871: 125 (transfer).
Siphlonurus flavidus. – Ulmer, 1920b: 135 (transfer).

Accepted name: *Siphlonurus flavidus* (A.-E. Pictet, 1865).

Locus typicus: "… à San Ildefonso…".

Type material: MHNG; lectotype, ♂ imago [Puthz design.]; 620 Granjas 48 coll. Pictet / 156 female [sic] / Siphlonurus flavidus (Pictet) (= Baetis flavida) Pictet, V. Puthz vide 1969, spec. in alcohol, wings & genitalia on microsc. slides. – MHNG; 2 ♂ and 1 ♀; same data as for lectotype; also in alcohol.

Remarks: Puthz (1977) redescribed the species from the type series and designated a lectotype. This taxon seems to be endemic to the Iberian Peninsula.

Baetis sylvicola A.-E. Pictet, 1865

Baetis sylvicola A.-E. Pictet, 1865: 24, pl. 3, figs 7-12.
Heptagenia sylvicola. – Eaton, 1871: 147 (transfer).
Epeorus sylvicola. – Eaton, 1887: 6 (transfer).

Accepted name: *Epeorus sylvicola* (A.-E. Pictet, 1865).

Locus typicus: "… à San Ildefonso…".

Type material: MHNG; ♂ lectotype [Puthz design.]; Baetis sylvicola Edouard Pictet / 4 males / Granjas Juillet 1859 / 4 / 620 Granjas 48 Espagne coll. Pictet / Epeorus sylvicola (Pictet) (= Baetis sylvicola Pictet) male / LECTOTYPUS Puthz 1971 Genitalia im mikrosk. Präp.

Remarks: Besides the lectotype and according to Puthz (1973c), two other specimens have been transferred to ethanol. Two damaged paralectotypes are still pinned, but only the thorax of one specimen and the thorax and hind legs of the other are still present. One specimen has a label saying "Hind wing of Epeorus sylvicola Ed Pictet, Eaton exam[inavit]. " and the other the following: "Epeorus sylvicola (A.-E. Pictet) Syntypes because of fragmental character not designated as paralectotypes PUTHZ, 1971".
Since Puthz (1973c), it has been admitted that the central European species known as *Epeorus assimilis* Eaton, 1885 is a junior subjective synonym of *E. sylvicola*. However, more recent investigations by Thomas *et al.* (2000) indicate that *E. assimilis* is a closely related but distinct taxon. Hence, *E. sylvicola* seems restricted to the Iberian Peninsula and also to North Africa.

OTHER MAYFLY TAXA DESCRIBED FROM SPECIMENS OF THE PICTET COLLECTION

In order to avoid presenting the complicated nomenclatural history of these taxa, we list them with their current names in this chapter and in the following one.

Ecdyonurus (Helvetoraeticus) picteti (Meyer-Dür, 1864)

Baetis sp. ? *Picteti* Meyer-Dür, 1864: 221.
Heptagenia Picteti. – Eaton, 1871: (transfer).
Ecdyonurus picteti. – Puthz, 1975: 321 (transfer).
Ecdyonurus (*Helvetoraeticus*) *picteti.* – Bauernfeind & Soldán, 2012: 279 (transfer to new subgenus).

Locus typicus: „… Muraglbach bei Pontresina, im Rosegthal, am Chalchagn und am Bernina bis 6700' ü.M…".

Type material: MHNG; lectotype, ♀ subimago; 620 Engadin 48 Alpes coll. Pictet / val Muragl 25 (6) / Baetis Picteti Meyer Engadin / Ecdyonurus picteti (Meyer-Dür) ♀ Lektotypus Puthz 1973 (Fig. 7).

Remarks: Puthz (1975) was the first to rediscover specimens of this species in F.-J. Pictet's collection. Besides the lectotype, there is another female subimago with the following labels: 620 Pontresina 48

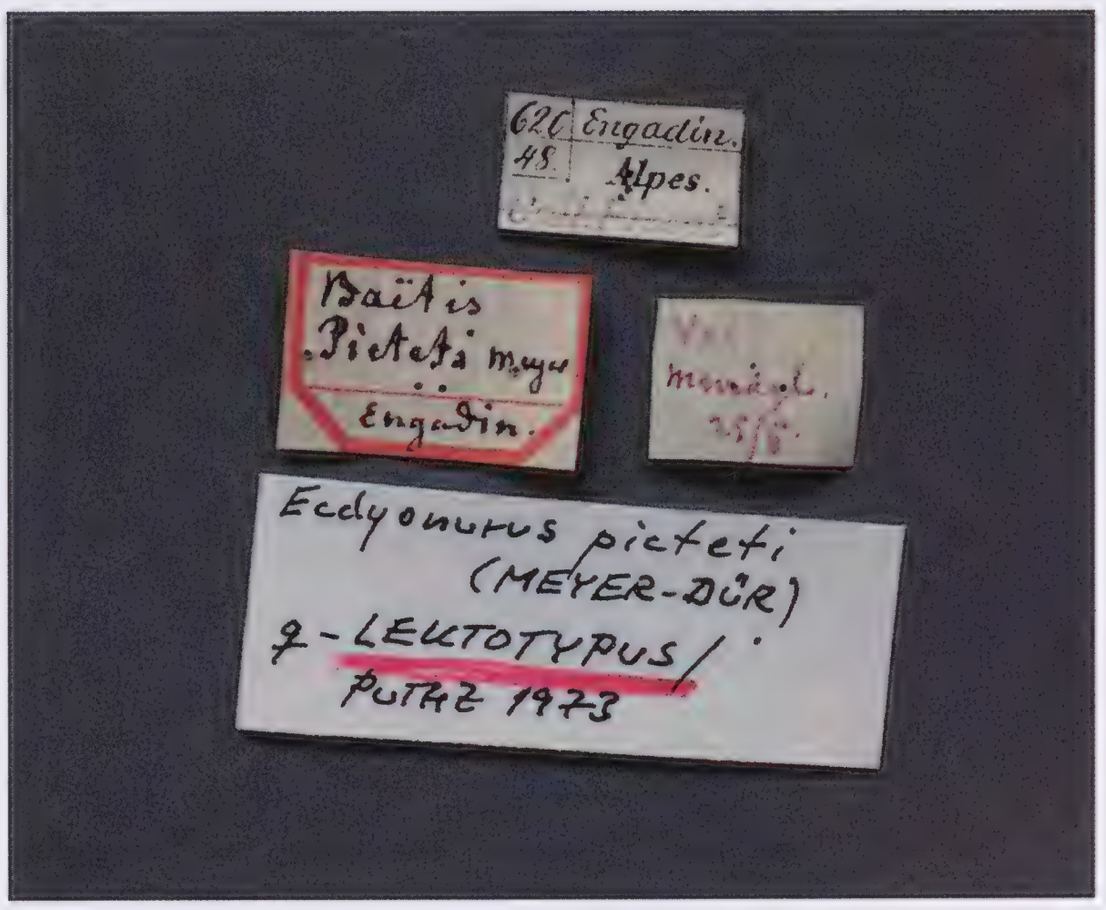


Fig. 7. *Ecdyonurus* (*Helvetoraeticus*) *picteti* (Meyer-Dür, 1864). Labels of the female subimago lectotype.

Alpes coll. Pictet / Pontresina 5/6 selten / Ecdyonurus picteti (Meyer-Dür) ♀ Paralektotypus Puthz 1973. Furthermore, there is a third one, also a female subimago, which does not belong to this species: 620 Bernina 48 6700' Alpes coll. Pictet / Bernina bis 6700' 4/6 / Syntypus von Baetis picteti Meyer-Dür = cf. Ecdyonurus venosus (F.) Puthz 1973.

Choroterpes picteti (Eaton, 1871)

Potamanthus marginatus. – F.-J. Pictet, 1843-1845: 208-211, pl. 55, figs 4-5 (nec *Ephemera marginata* Linné, 1767; misidentification).
Leptophlebia Picteti Eaton, 1871: 87 (original description).
Habrophlebia Picteti. – Eaton, 1881: 195 (transfer).
Choroterpes picteti. – Eaton, 1884: 105 (transfer).

Locus typicus: "… aux environs de Genève…".

Type material: Syntypes (male and female imago, female subimago), not traced and probably lost.

Remarks: From F.-J. Pictet's text and illustrations it is clear that he based his descriptions on material from the surroundings of Geneva. Obviously Eaton (1871) based his description of *Leptophlebia picteti* only on F.-J. Pictet's description of *P. marginatus,* which he literally translated into Latin, and according to the International Commission on Zoological Nomenclature (1999: article 72.4.2) the type series consists of the material originally examined by F.-J. Pictet. When Eaton erected the genus *Choroterpes* Eaton, 1881, he based it exclusively on his new species *C. lusitanica* Eaton, 1881. It was only later (Eaton, 1884: 105) that he considered *C. lusitanica* a junior subjective synonym of *C. picteti* and consequently used this name for the type species of *Choroterpes*.
In the MHNG exists at least one specimen which had

been examined by Eaton: male / 620 48 Espagne coll. Pictet / 66 / 31 / M. 2 Selys Longchamps / Chloroterpes [sic] Picteti Eaton Eaton type. The material is in alcohol and in poor condition, in several pieces, and it is completely faded, as are the labels. The origin of the specimen (Spain) indicates that it came from A.-E. Pictet's collection and was seen and labelled by Eaton himself, but obviously at a later time than the original description in 1871. The specimen is most probably not part of the original type series and therefore not available for lectotype fixation (International Commission on Zoological Nomenclature, 1999: article 74.1) and Eaton's remark on the label ("type") cannot be understood as a valid neotype designation (International Commission on Zoological Nomenclature, 1999: article 75.3).
There is also a pinned specimen in the MHNG placed under the name *Leptophlebia marginata* L. It is a male subimago with the following labels: 620 Burgdorf 48 Suisse coll. Pictet / Pot. Marginatus. This specimen (probably collected by Meyer-Dür) also belongs to *C. picteti* but can also not be considered to represent type material.

Teloganopsis hispanica (Eaton, 1888)

Ephemerella hispanica Eaton, 1888: 306.
Serratella hispanica. – Gonzalez del Tanago & Garcia de Jalon, 1983: 149 (transfer).
Teloganopsis hispanica. – Jacobus & McCafferty, 2008: 241 (transfer).

Locus typicus: "Spain, San Ildefonso, Segovia".

Type material: MHNG; syntype, ♂ imago; 620 48 Espagne coll. Pictet / n°5 Potam. / 22 / Potam. n.sp./ Ephemerella hispanica Eaton MS sp. nov. Eaton type [abdomen missing] (Fig. 8). – Rijksmuseum van Natuurlijke Historie, Leiden; syntype, female subimago.

Remarks: The MHNG specimen is damaged and was already broken when Eaton (1888) described it, since he gave no information about abdominal colouration, forceps and cerci. Nevertheless, the specimen fits well the concept that following taxonomists have applied (Studemann & Tomka, 1987), especially regarding the shape of fore and hind wings.
The second syntype (a female subimago, "female allotype" sensu Kimmins, 1960: 304) should be in Herman Albarda's collection at the Rijksmuseum van Natuurlijke Historie in Leiden, The Netherlands.

Fig. 8. *Teloganopsis hispanica* (Eaton, 1888). Male imago holotype. Scale bar: 1 mm.

Rhithrogena picteti Sowa, 1971

Baetis semicolorata. – F.-J. Pictet, 1843-1845: 208-211, pl. 22, figs 4-7 (nec *Baetis semicolorata* Curtis, 1834; misidentification).
Rhithrogena semitincta. – Kimmins, 1936: 280, fig. 2 (nec *Baetis semitincta* Pictet, 1843; misidentification).
Rhithrogena picteti Sowa, 1971: 903 (original description).

Locus typicus: "… la Versoix à Richelien…".

Type material: MHNG; holotype, ♂ imago; bords de la Versoix à Richelien vers 450 m.; 19.V.1968; leg J.C. Régnier. – MHNG; paratypes, 3 ♂ imagines; same data as for holotype.

Remarks: Sowa (1971) described this species based on fresh material collected by J.-C. Régnier, a former technician at the MHNG, in the Versoix River, close to Geneva. In the F.-J. Pictet collection at the MHNG there are several pinned specimens which had also been studied by Kimmins (in part; 1936) and by Sowa. However, contrary to what Sowa stated, these specimens do not constitute the "original material" studied by F.-J. Pictet ("… commune dans les ruisseaux des environs de Genève"). The old MHNG series consists of 12 male imagines labelled: 620 Hindelbank 48 Suisse coll. Pictet / Rh. semicolorata Curtis / Rhithrogena picteti Det. R. Sowa. This locality is not mentioned in the original work of F.-J. Pictet and the material was certainly collected later by Meyer-Dür.

Asthenopodes picteti Hubbard, 1975

Palingenia albicans Percheron in Guerin & Percheron, 1838. – F.-J. Pictet, 1843-1845: 149-150, pl. 13, figs 1-3 (nec *Ephemera albicans* Percheron in Guérin & Percheron, 1838; misidentification).
Asthenopus albicans (F.-J. Pictet, 1843) (unavailable species name). – Ulmer, 1921: 239 (transfer).
Asthenopodes albicans (F.-J. Pictet, 1843) (unavailable species name). – Ulmer, 1924a: 27 (transfer).
Asthenopodes picteti Hubbard, 1975: 111 (establishment of available species name). – Molineri *et al.*, 2015: 73 (reverse transfer).
Asthenopus picteti. – Hubbard & Domínguez, 1988: 209 (transfer).

Locus typicus: "… il provient du Brésil" [Rio de Janeiro province, Brasil].

Type material: NMW; 1 ♂, presumably a syntype; Shtt[= Schott]. [blue paper] / Pictet vidit / *Asthenopus albicans* Pict. Type [Ulmer's handwriting] / TYPE

[printed on red paper]. Damaged, most legs, hind wings and abdomen missing. – NMW; 1 ♂, presumably a syntype; Pb [= probably reads Paraíba, collected by Schott]. [blue paper] / Pictet vidit / *Campsurus truncatus* Ulmer [in Ulmer's handwriting].

Remarks: The status of the NMW material is not altogether clear; these are probably syntypes (male imagines). The first specimen had been collected by H.W. Schott during 1817-1821 in Brazil, Rio de Janeiro province. Although F.-J. Pictet stated "L'exemplaire figuré m'a été communiqué par le Musée de Vienne, …", Ulmer (1921: 239) found two male specimens arranged under the name *Palingenia albicans* Pictet and identified the second specimen as *Campsurus truncatus* Ulmer, 1920a.
It is not known whether F.-J. Pictet really examined both specimens or rather Kollar later added a second male when he labelled the material. F.-J. Pictet's description and illustration, however, agree with the specimen labelled "type" by Ulmer, suggesting that this specimen actually represents the holotype by monotypy.
Palingenia albicans F.-J. Pictet, 1843 nec *Ephemera albicans* Percheron, 1838, which was transferred as *Campsurus albicans* by Eaton (1883), has a long and controversial nomenclatural history. *Palingenia albicans* F.-J. Pictet, 1843 is actually a misidentification, not a formally established species name. Ulmer (1924b) based his genus *Asthenopodes* on this incorrectly named taxon, and Hubbard (1975) proposed a valid name (*nomen novum*) in honour of F.-J. Pictet, because the species-group name used by Ulmer was not available (species-group name wrongly applied through misidentification; International Commission on Zoological Nomenclature, 1999: article 49).

OTHER VALUABLE MAYFLY SPECIMENS HOUSED IN NMW AND MHNG

During the preparation of his monograph, F.-J. Pictet also used several specimens from the Vienna Museum collection for his (re)descriptions of taxa of previous authors. Usually they are recognizable by the label "Pictet vidit". The collection in Geneva houses some uncommon species, which are also briefly listed here.

Hexagenia limbata (Serville in Guerin, 1829)

Ephemera limbata Serville in Guérin, 1829: 384, pl. 60, figs 7-9.
Palingenia limbata. – F.-J. Pictet, 1843-1845: 146-148, pl. 12, figs 1-3 (transfer).
Hexagenia limbata. – Walsh, 1863: 197 (transfer).

Material: NMW; ♂ subimago; Am[erica]. s[eptentrionalis]. Parreyss / Pictet vidit. – NMW; ♀ subimago; 190 Par[reyss]. / Pictet vidit; legs and abdomen missing. – NMW; 1 ♀ subimago; Pictet vidit; fore legs and tip of left fore wing missing.

Remarks: F.-J. Pictet (1843: 148) mentioned only two specimens from Vienna, figured on plate XII, fig. 1 (male) and fig. 3 (female). For a detailed discussion of Serville's material see Ulmer (1921: 233-239). Ludwig Parreyss (1796-1879) was an established dealer in natural history specimens (mostly insects and birds) in Vienna and the MNW acquired very frequently material from him.

Campsurus dorsalis (Burmeister, 1839)

Palingenia dorsalis Burmeister, 1839: 803. – F.-J. Pictet, 1843-1845: 153-154, pl. 13, fig. 5.
Campsurus dorsalis. – Eaton, 1883: 41 (transfer).

Material: NMW; 6 ♀ subimagines; N[atterer]. c[ollectio]. Y[panema]. [blue paper; presumably collected by J. Natterer in Ipanema, Sao Paulo, Brasil, 23°26'S 47°36'W] / Pictet vidit [slightly damaged].

Remarks: F.-J. Pictet mentioned only "deux exemplaires qui m'ont été communiqués par le musée de Vienne". It seems probable that Kollar sent just a sample (2 specimens) to F.-J. Pictet but afterwards labelled the complete series accordingly.

Palingenia longicauda (Olivier, 1791)

Ephemera longicauda Olivier, 1791: 418.
Palingenia longicauda. – F.-J. Pictet, 1843-1845: 155-157, pl. 14, 14bis, 15, fig. 1 (transfer).

Material: NMW; 2 ♂ imagines; Ungarn, Friv[aldszky leg.].

Remarks: F.-J. Pictet (1843: 157 "de Hongrie") mentioned specimens provided by Kollar. This probably relates to the mentioned material, but no specimens with F.-J. Pictet's label are to be found in the NMW collection.

Baetis fuscatus (Linnaeus, 1761)

Ephemera bioculata Linnaeus, 1758: 547 [*nomen suppressum*; see International Commission on Zoological Nomenclature, 1966: 209].
Cloe bioculata (Linnaeus, 1758). – Pictet, 1843-45: 244, pl. 4-35 (transfer).
Baetis fuscatus (Linnaeus, 1761). – Eaton, 1871: 111 (synonymization).

Material: NMW; 5 ♂ imagines [without data]; Pictet vidit / *Baetis venustulus* Etn. [Ulmer's handwriting].

Remarks: F.-J. Pictet (1843: 244) did not expressly mention any specimens from Austria.

Alainites muticus (Linnaeus, 1758)

Cloe pumila. – F.-J. Pictet, 1843-1845: 253, pl. 40, fig. 2. (nec *Cloe pumila* Burmeister, 1839; misidentification).
Baetis pumilus. – Eaton, 1870: 5 (transfer).
Baetis muticus (Linnaeus, 1758). – Bengtsson, 1912: 7 (synonymization).
Alainites muticus (Linnaeus, 1758). – Waltz *et al.*, 1994: 34 (transfer).

Material: NMW; 3 ♂ imagines; "Pictet vidit", one male labelled "Baden [about 22 km southeast of Vienna], Kollar".

Remarks: F.-J. Pictet mentioned "M. Kollar m'en a communiqué quelques exemplaires des environs de Vienne". A female specimen of *B. muticus* bears the label: *vitreipennis* Kllr Pictet Aust[ria] [Kollar's handwriting?] / *Baetis pumilus* Burm. [Ulmer's handwriting]. Kollar's manuscript name "Cloe vitreipennis" obviously has never been published and is therefore a *nomen nudum*.

Caenis horaria (Linnaeus, 1758)

Caenis lactea. – F.-J. Pictet, 1843-1845: 276-277, pl. 43, figs 1-4, pl. 44 (nec *Oxycypha lactea* Burmeister, 1839; misidentification).
Caenis horaria (Linnaeus, 1758). – Jacob, 1974: 94.

Material: NMW; 2 ♂ imagines, 1 ♂ subimago; coll. Nat. Mus. Wien [without locality data].

Remarks: F.-J. Pictet did not mention that he received material from Kollar, but in the NMW three specimens presumably had originally been deposited under the name *Caenis lactea* Pictet and identified by Malzacher as: *Caenis horaria* (Linnaeus, 1758) / Malzacher det. 1983.

Caenis luctuosa (Burmeister, 1839)

Oxycypha luctuosa Burmeister, 1839: 797.
Caenis luctuosa. – F.-J. Pictet, 1843-1845: 283-284, pl. 45, fig. 3 (transfer).

Material: NMW; 1 ♂, 1 ♀ (without data); Pictet vidit / Caenis luctuosa (Burmeister, 1839) / Malzacher det. 1983.

Remarks: F.-J. Pictet did not mention that he received material from Kollar. The female specimen presumably had originally been placed under *Caenis oophora* (see above).

Ametropus fragilis Albarda, 1878

Ametropus fragilis Albarda, 1878: 129.

Material: MHNG; 1 ♂ imago; 600 81 Italie Anc[ienne] Coll[ection] / 192 61 / 30 / Ametropus fragilis Albarda Eaton determ. [abdomen broken, remaining parts with fungal growth] (Fig. 9B).

Remarks: This specimen is intriguing. The identification made by Eaton is correct, because it is based on the peculiar arrangement of veins in the cubital and anal fields (Fig. 9A). Eaton (1885) did not mention this specimen from Italy, restricting the distribution of the species to the type locality in Holland. It is therefore possible that the specimen was identified by Eaton after the publication of his monograph. The first record of *A. fragilis* from Italy was by Turin *et al.* (1997). These authors suspected this surprising discovery to be due to a recent introduction with fishes from Eastern Europe. The fact that this specimen was collected more than 150 years ago indicates that further investigations on the distribution of this species in Italy are needed and that its occurrence may be natural. The recent discovery of *A. fragilis* in Croatia points in the same direction (Cuk *et al.*, 2015).

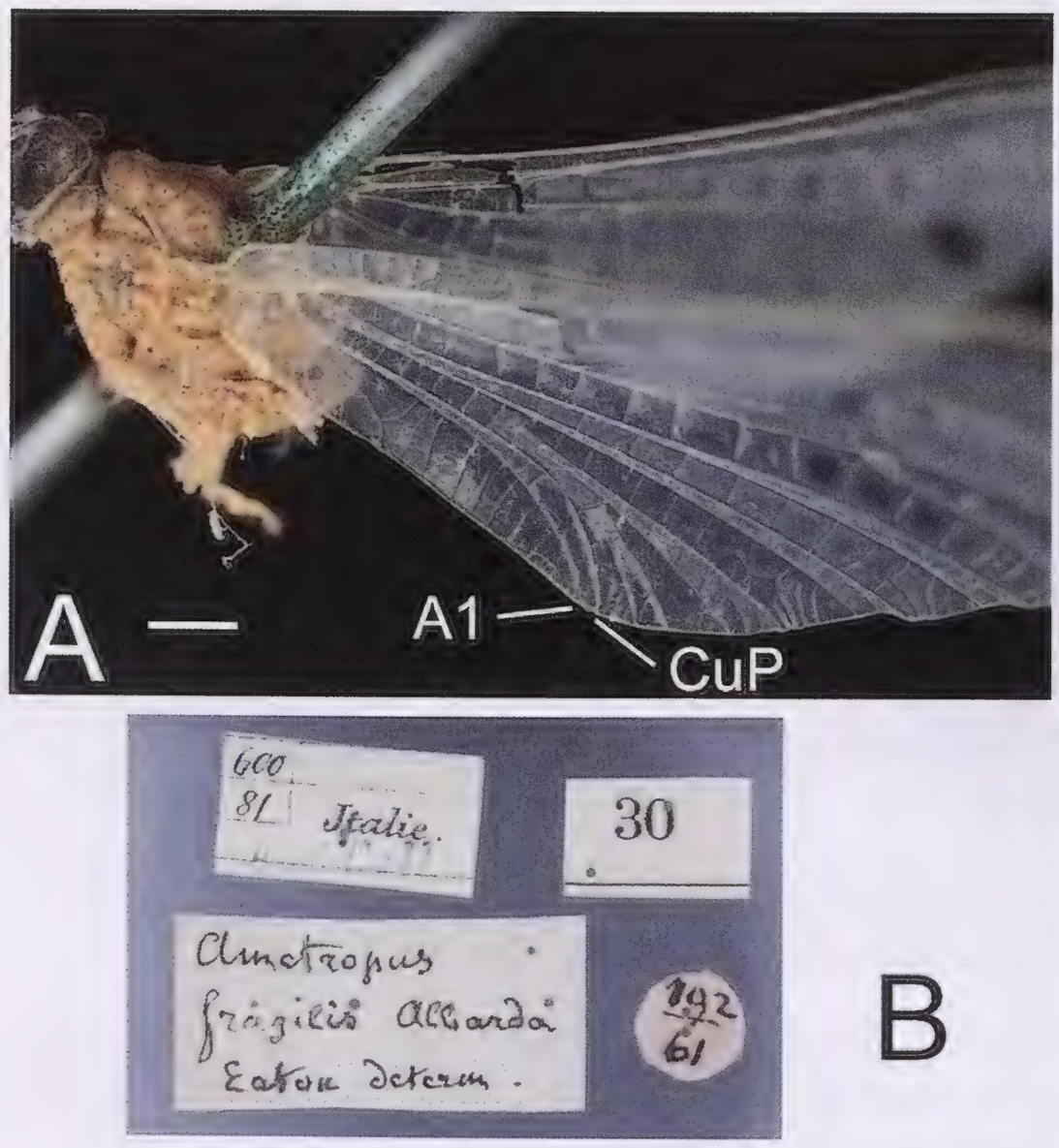


Fig. 9. *Ametropus fragilis* Albarda, 1878. (A) Male imago in dorso-lateral view; A1: first anal vein, CuP: posterior cubital vein. Scale bar: 1 mm. (B) Corresponding labels.

Rhithrogena cincta Navás, 1921

Rhithrogena cincta Navás, 1921: 14, fig. 1. – Thomas, 1968a: 212 (lectotype designation).

Material: MHNG; 1 ♂ imago; 620 Pyrénées 48 Espagne coll. Pictet / Pyrénées Juillet 1859 / 149 [handwriting] / 24 [printed] / Pot[amanthus] n. sp. / Rhithrogena aurantiaca Burm. Eaton determ. [fore legs

missing, forewings damaged, genitalia rehydrated and put in microvial with glycerine].

Remarks: This specimen has certainly been collected by A.-E. Pictet on his way back to Geneva when he left San Ildefonso in mid July 1859. The identification by Eaton followed the common interpretation of *Baetis aurantiaca* at that time. Since then, it has been shown that Burmeister's concept of *R. aurantiaca* applies to an *Ecdyonurus* species (Puthz, 1973b). *Rhithrogena cincta* has been redescribed by Thomas (1968a), who designated from Navás' collection a lectotype originating from Vilallonga in the Spanish Pyrenees. The specimen collected by A.-E. Pictet completely fits the diagnosis proposed by Thomas (1968a), particularly in the shape of the styliger plate with well marked postero-lateral protuberances, in the marking of the abdomen, and in the marking of the coxae with two elongated stripes (see Thomas 1968a: pl. I, figs 2-3, pl. II, fig. 2 and Fig. 10). Penes lobes clearly correspond to those of the *diaphana*-group, but differences between *R. diaphana* and *R. cincta* are insignificant. The status of this species should be solved on the basis of new material. This specimen is only the second one known for this species.

Fig. 10. *Rhithrogena cincta* Navás, 1921. Male imago in lateral view. Scale bar: 1 mm.

ACKNOWLEDGMENTS

We are especially indebted to the curators of different museums for their invaluable help during the long duration of this research: Dr Bernd Hauser and later Dr Peter Schwendinger, curators at the MHNG, for their hospitality and for allowing us to study their collections; Jean Legrand (Muséum National d'Histoire Naturelle, Paris) for accepting to make inquiries in the collections for us, as well as for his hospitality during our numerous stays in Paris; Jean-Paul Haenni, former curator at the Musée d'histoire naturelle de Neuchâtel; Director Dr Christa Riedl-Dorn (Archivabteilung, NMW) for making Pictet's letter available to us, and to Director Mag. Dr Martin Lödl (Dept. II. Zoology-Insecta, NMW) and Curator Dr Susanne Randolf (Insecta varia, NMW) for their extended hospitality. We are most indebted to Mr Laurent Christeller, Historical Archival Manager at the Fondation des Archives de la Famille Pictet, Geneva, for his help and for providing a painting of F.-J. Pictet. Finally our sincere gratitude goes to Dr Arne Haybach (Saarbrücken) and John Hollier (MHNG) for their constructive remarks, and to Dr Peter Schwendinger for his help in editing the manuscript.

REFERENCES

Albarda H. 1878. Descriptions of three new European Ephemeridae. *Entomologist Monthly Magazine* 15: 128-130.

Aubert J. 1947. Notes sur la collection de Plécoptères du Muséum d'Histoire Naturelle de Genève (coll. Pictet). *Revue suisse de Zoologie* 54: 545-552.

Bae Y.J., McCafferty W.P. 1991. Phylogenetic systematics of the Potamanthidae (Ephemeroptera). *Transactions of the American Entomological Society* 117(3-4): 1-143.

Bauernfeind E. 1990. Der derzeitige Stand der Eintagsfliegen-Faunistik in Österreich (Insecta: Ephemeroptera). *Verhandlungen der zoologisch-botanischen Gesellschaft, Wien* 127: 61-82.

Bauernfeind E. 1991. *Rhithrogena zernyi* sp. n., ein neuer Vertreter der *diaphana*-Gruppe aus Jugoslawien (Insecta: Ephemeroptera). *Annalen des Naturhistorischen Museums in Wien* 92 (Serie B): 135-138.

Bauernfeind E., Haybach A. 2012. Case 3594. *Ecdyonurus* Eaton, 1868 and *Ephemera venosa* Fabricius, 1775 (currently *Ecdyonurus venosus*; Insecta, Ephemeroptera): proposed conservation of usage by designation of a neotype under ICZN (1999) Article 75.6. *Bulletin of Zoological Nomenclature* 69(4): 254-259.

Bauernfeind E., Soldán T. 2012. The Mayflies of Europe. *Apollo Books*, *Ollerup* [now: Brill Publ., Leiden], 781 pp.

Bengtsson S. 1912. An analysis of the Scandinavian species of Ephemerida described by older authors. *Arkiv för Zoologi* 7(36): 1-21.

Bisconti R., Canestrelli D., Tenchini R., Belfiore C., Buffagni A., Nascetti G. 2016. Cryptic diversity and multiple origins of the widespread mayfly species group *Baetis rhodani* (Ephemeroptera: Baetidae) on northwestern Mediterranean islands. *Ecology and Evolution* 6(21): 7901-7910.

Botosaneanu L., Schmid F. 1973. Les Trichoptères du Muséum d'Histoire Naturelle de Genève (situation en 1970-1971). *Revue suisse de Zoologie* 80(1): 221-256.

Brauer F. 1876. Die Neuropteren Europas und insbesondere Oesterreichs mit Rücksicht auf ihre geographische Verbreitung [pp. 263-300]. *In:* Festschrift zur Feier des fünfundzwanzigjährigen Bestehens der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft Wien. *F.A Brockhaus, Leipzig*, 396 pp.

Brauer F. 1878. Verzeichnis der Neuropteren Deutschlands und Österreichs. II. *Entomologische Nachrichten* 4(7): 85-90.

Brauer F. 1885. Neuroptera des Gebietes von Herrnstein in Niederösterreich und der weiteren Umgebung [pp. 19-27]. *In:* Becker M.A. (ed.), Herrnstein in Niederösterreich 2(2). *Adolf Holzhausen, Wien*, 247 pp.

Brauer F., Löw F. 1857. Neuroptera austriaca. Die im Erzherzogthum Oesterreich bis jetzt aufgefundenen Neuropteren nach der analytischen Methode zusammengestellt, nebst

einer kurzen Charakteristik aller europäischen Neuropteren-Gattungen. *Gerold, Wien,* XXIII + 74 pp., 5 lithograph. Tafeln.

Burmeister H. 1839. Ephemerina. *Handbuch der Entomologie* 2(2): 788-804.

Chopra B. 1928 (for 1927). The Indian Ephemeroptera (mayflies). *Records of the Indian Museum* 39: 91-138.

Cruz P.V., Salles F.F., Hamada N. 2017. Phylogeny of *Callibaetis* (Ephemeroptera: Baetidae) based on morphology of nymphs and adults. *Zoologica Scripta* 46(2): 138-149.

Cuk R., Cmrlec K., Belfiore C. 2015. The first record of *Ametropus fragilis* Albarda, 1878 (Insecta: Ephemeroptera) from Croatia. *Natura Croatica* 24(1): 151-157.

Curtis J. 1834. Descriptions of some nondescript British species of May-flies of anglers. *London and Edinburgh Philosophical Magazine and Journal of Science* (3)4(20): 120-125.

Domínguez E., Molineri C., Pescador M.L., Hubbard M.D., Nieto C. 2006. Ephemeroptera of South America. *Pensoft Press, Sofia and Moscow*, 650 pp.

Dufour L. 1841. Recherches anatomiques et physiologiques sur les Orthoptères, les Hyménoptères et les Névroptères. *Mémoires de l'Académie des Sciences de l'Institut Impérial de France* 7:265-647.

Eaton A.E. 1868. An outline of re-arrangement of the genera of Ephemeridae. *Entomologist's Monthly Magazine* 5: 82-91.

Eaton A.E. 1870. On some new British species of Ephemeridae. *Transactions of the Entomological Society of London* 1870(1): 1-8.

Eaton A.E. 1871. A monograph of the Ephemeridae. *Transactions of the Entomological Society of London* 1871: 1-164.

Eaton A.E. 1881. An announcement of new genera of the Ephemeridae. *Entomologist's Monthly Magazine* 17: 191-197.

Eaton A.E. 1883-1888. A revisional monograph of recent Ephemeridae or mayflies. *Transactions of the Linnean Society of London* (2nd Ser. Zoology) 2: 1-352.

Fabricius J.C. 1775. Systema entomologicae, sistens insectorum classes, ordines, genera, species, adjectis synonymis, locis, descriptionibus, observationibus. *Officina Libraria Kortii, Flensburgi, Lipsiae*, 832 pp.

Fabricius J.C. 1777. Genera insectorum eorumque characteres naturales secundum numerum, figuram, situm et proportionem omnium partium oris adiecta mantissa specierum nuper detectarum. *M. F. Bartschii, Chilonii (=Kiel),* i-xiv + 310 pp + 16 pl.

Fitzinger L.J. 1868a. Geschichte des kais. - königl. Hof - Naturalien-Cabinetes zu Wien. II. Abtheilung: Periode unter Franz II. (Franz I. Kaiser von Österreich) bis zu Ende des Jahres 1815. *Sitzungsberichte der mathematisch - naturwissenschaflichen Klasse der kaiserlichen Akademie der Wissenschaften* 58(1): 1013-1092.

Fitzinger L.J. 1868b. Geschichte des kais. - könig. Hof - Naturalien-Cabinetes zu Wien. III. Abtlg.: Periode unter Kaiser Franz I. von Österreich von 1816 bis zu dessen Tode 1835. *Sitzungsberichte der mathematisch - naturwissenschaftlichen Klasse der kaiserlichen Akademie der Wissenschaften* 57(1): 35-120.

Fitzinger L.J. 1880a. Geschichte des k. k. Hof-Naturalien-Cabinetes in Wien. IV. Abtheilung. Periode unter Kaiser Ferdinand I. von Österreich von 1830 bis zu Ende des Jahres 1841. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe* 81: 267-329.

Fitzinger L.J. 1880b. Geschichte des k. k. Hof-Naturalien-Cabinetes in Wien. V. Abtheilung. Periode unter Kaiser Ferdinand I. von Österreich von 1842 bis zum Rücktritte des Kaisers von der Regierung Anfang Dezember 1848. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe* 82: 279-339.

Flowers R.W., Peters W.L. 1981. *Stenonema mexicana* (Heptageniidae: Ephemeroptera) in southern Central America. *Entomological News* 92(4): 152-154.

Gattolliat J.-L., Cavallo E., Vuataz L., Sartori M. 2015. DNA barcoding of Corsican mayflies (Ephemeroptera) with implications on biogeography, systematics and biodiversity. *Arthropod Systematics & Phylogeny* 73(1): 3-18.

Gattolliat J.-L., Sartori M. 2008. What is *Baetis rhodani* (Pictet, 1843) (Insecta, Ephemeroptera, Baetidae)? Designation of a neotype and redescription of the species from its original area. *Zootaxa* 1957: 69-80.

Gonzalez del Tanago M., Garcia de Jalon D. 1983. New Ephemerellidae from Spain (Ephemeroptera). *Aquatic Insects* 5(3): 147-156.

Guérin E. 1829-1844. Iconographie du règne animal de G. Cuvier: ou, représentation d'après nature de l'une des espèces les plus remarquables, et souvent non encore figurées, de chaque genre d'animaux. Avec un texte descriptif mis au courant de la science. *J. B. Baillière, Paris,* 217 plates.

Guérin E., Percheron A. 1838. Genera des insectes, ou exposition détaillée de tous les caractères propres à chacun des genres de cette classe d'animaux. Part 6, 10 pl., *Méquignon-Marvis, père et fils, Paris,* 358 pp.

Hagen H.A. 1855. Die Ephemeriden-Gattung *Oligoneuria*. *Entomologische Zeitung, Stettin* 16: 262-270.

Hagen H. 1888. Unsere gegenwärtige Kenntniss der Ephemeren. *Stettiner Entomologische Zeitung* 49(7-9): 221-232.

Harker J.E. 1954. The Ephemeroptera of Eastern Australia. *Transactions of the Royal Entomological society of London* (ser. B) 105(12): 241-268.

Haybach A. 2010. Katalog der aus Deutschland, Österreich und der Schweiz bekannten Eintagsfliegen und ihrer Synonyme (Insecta, Ephemeroptera). *Mainzer Naturwissenschaftliches Archiv* 32: 1-75.

Hubbard M.D. 1975. The genus *Asthenopodes* Ulmer and its type species (Ephemeroptera: Polymitarcidae). *The Florida Entomologist* 58(2): 111-112.

Hubbard M.D., Domínguez E. 1988. Synonymy of the neotropical mayfly genera *Asthenopus* and *Asthenopodes* (Ephemeroptera: Polymitarcyidae: Asthenopodinae). *The Florida Entomologist* 71(2): 207-210.

Imhoff L. 1852. *Oligoneuria rhenana. Bericht über die Verhandlungen der Naturforschenden Gesellschaft in Basel* 10: 177-180.

International Commission on Zoological Nomenclature 1966. Opinion 787. *Ephemera bioculata* Linnaeus, 1758 suppressed under the plenary power for the purposes of the Principle of Priority but not for those of the Principle of Homonymy. *Bulletin of Zoological Nomenclature* 23(5): 209.

International Commission on Zoological Nomenclature 1999. International Code of Zoological Nomenclature. *International Trust for Zoological Nomenclature, London*, 306 pp.

International Commission on Zoological Nomenclature 2015. Opinion 2356 on Case 3594. *Ecdyonurus* Eaton, 1868 and

Ephemera venosa Fabricius (currently *Ecdyonurus venosus*; Insecta, Ephemeroptera): usage conserved by designation of a neotype for *Ephemera venosa*. *Bulletin of Zoological Nomenclature* 72(2): 162-163.

Jacob U. 1974. Zur Kenntnis zweier *Oxycypha*-Arten Hermann Burmeisters (Ephemeroptera, Caenidae). *Reichenbachia* 15(14): 93-97.

Jacob U. 1993. Zur Systematik und Verbreitung der europäischen Ephemerellidae (Ephemeroptera). *Verhandlungen Westdeutscher Entomologentag* 1992: 101-110.

Jacobus L.M., McCafferty W.P. 2008. Revision of Ephemerellidae genera (Ephemeroptera). *Transactions of the American Entomological Society* 134(1-2): 185-274.

Kimmins D.E. 1936. *Rhithrogena semicolorata* Curtis and *R. semitincta* Pictet (Ephemeroptera). *The Entomologist* 69: 279-280.

Kimmins D.E. 1942a. Notes on Ephemeroptera. *The Entomologist* 75: 121-125.

Kimmins D.E. 1942b. The British species of the genus *Ecdyonurus* (Ephemeroptera). *Annals and Magazine of Natural History* 11(9): 486-507.

Kimmins D.E. 1960. The Ephemeroptera types of species described by A.E. Eaton, R. McLachlan and F. Walker, with particular reference to those in the British Museum (Natural History). *Bulletin of the British Museum (Natural History), Entomology* 9(4): 269-318.

Kluge N.J. 2010. Redescription of the taxon Tricorygnatha (Ephemeroptera, *Tricorythus* s.l.) based on new findings in Africa and Indonesia. *Russian Entomological Journal* 19(2): 79-104.

Kluge N.J. 2020. Ephemeroptera of the world. Available at http://www.insecta.bio.spbu.ru [accessed 20.04.2020].

Leach W.E. 1815. Entomology. *Brewster's Edinburgh Encyclopaedia* 9: 57-172.

Lestage J.-A. 1917. Contribution à l'étude des larves des Ephémères paléarctiques. *Annales de Biologie Lacustre* 8(3/4): 213-458.

Lestage J.-A. 1921. Les Ephémères indo-chinoises. *Bulletin et Annales de la Société Entomologique de Belgique* 61: 211-222.

Linnaeus C. 1758. Systema Naturae, ed. X. *L. Salvii, Holmiae*, 824 pp.

Linnaeus C. 1761. Fauna Svecica sistens Animalia Sveciae regni: mammalia, aves, amphibia, pisces, insecta, vermes. Distributa per classes & ordines, genera & species, cum differentiis specierum, synonymis auctorum, nominibus incolarum, locis natalium, descriptionibus insectorum. *L. Salvii, Holmiae*, 824 pp.

Linné C. a. 1767. Systema Naturae, ed. XII., vol. 1., pars II. *L. Salvii, Holmiae,* 1327 pp.

Lucentini L., Rebora M., Puletti M.E., Gigliarelli L., Fontaneto D., Gaino E., Panara F. 2011. Geographical and seasonal evidence of cryptic diversity in the *Baetis rhodani* complex (Ephemeroptera, Baetidae) revealed by means of DNA taxonomy. *Hydrobiologia* 673(1): 215-228.

Malzacher P. 1984. Die europäischen Arten der Gattung *Caenis* Stephens (Insecta: Ephemeroptera). *Stuttgarter Beiträge zur Naturkunde* (Serie A, Biologie) 373: 1-48.

Malzacher P. 1986. Diagnostik, Verbreitung und Biologie der europäischen *Caenis*-Arten (Ephemeroptera: Caenidae). *Stuttgarter Beiträge zur Naturkunde* (Serie A, Biologie) 387: 1-41.

McCafferty W.P. 1996. The Ephemeroptera species of North America and index to their complete nomenclature. *Transactions of the American Entomological Society* 122(1): 1-54.

McCafferty W.P., Bae Y.J. 1992. Taxonomic status of historically confused species of Potamanthidae and Heptageniidae (Ephemeroptera). *Proceedings of the Entomological Society of Washington* 94(1): 169-171.

Meyer-Dür L.R. 1864. Beobachtungen auf einer entomologischen Reise während des Sommers 1863 durch das Seegebiet von Tessin und Oberengadin. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* 1(7): 219-225.

Meyer-Dür L.R. 1874. Die Neuropteren-Fauna der Schweiz. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* 4(6): 281-436.

Molineri C. 2010. A cladistic revision of *Tortopus* Needham & Murphy with description of the new genus *Tortopsis* (Ephemeroptera: Polymitarcyidae). *Zootaxa* 2481: 1-36.

Molineri C., Salles F.F., Peters J.G. 2015. Phylogeny and biogeography of Asthenopodinae with a revision of *Asthenopus*, reinstatement of *Asthenopodes*, and the description of the new genera *Hubbardipes* and *Priasthenopus* (Ephemeroptera, Polymitarcyidae). *ZooKeys* 478: 45-128.

Müller O.F. 1776. Zoologiae Danicae Prodromus, seu Animalium Daniae et Norvegiae indigenarum characteres, nomina, et synonyma imprimis popularium. *Hallageri, Havniae [Copenhagen],* xxxii + 274 pp.

Müller-Liebenau I. 1969. Revision der europäischen Arten der Gattung *Baetis* Leach, 1815 (Insecta, Ephemeroptera). *Gewässer und Abwässer* 48/49: 1-214.

Navás L. 1921. Mis excursiones scientificas del verano de 1919. *Memorias de la Real Academia de Ciencias y Artes de Barcelona* 17: 143-169.

Needham J.G., Murphy H.E. 1924. Neotropical mayflies. *Bulletin of the Lloyd Library* (22, Entomological Serie) 4: 1-79.

Oliff W.D. 1960. Hydrobiological studies of the Tugela River System. Part I. The main Tugela River. *Hydrobiologia* 14(3-4): 281-385.

Olivier G.A. 1791. Encyclopédie méthodique. Histoire naturelle. Insectes. *Panchoucke, Paris*, 704 pp.

Peters J.G., Arvy L., Peters W.L. 1980. Pictet et Eaton: les premiers spécialistes des Ephéméroptères [pp. 531-537]. *In:* Flannagan J.F., Marshall K.E. (eds), Advances in Ephemeroptera Biology. *Plenum Press, New York,* 552 pp.

Pictet A.-E. 1865. Synopsis des Névroptères d'Espagne. *H. Georg, Genève*, 123 pp.

Pictet F.-J. 1834. Recherches pour servir à l'histoire et à l'anatomie des Phryganides. *A. Cherbuliez, Genève*, 240 pp. + 20 pl.

Pictet F.-J. 1841-1842. Histoire naturelle des Insectes Névroptères. Première monographie: Famille des Perlides. *J. Kessmann, Genève*, 446 pp. + 33 pl.

Pictet F.-J. 1843-1845. Histoire naturelle des Insectes Névroptères. Famille des Ephémérines. *J. Kessmann, Genève*, 300 pp. + 47 pl.

Pictet F.-J. 1846. Considérations générales sur les débris organiques qui ont été trouvés dans l'Ambre et en particulier sur les insectes. *Bibliothèque Universelle de Genève, Archives des sciences physiques et naturelles* 2: 5-16.

Pictet F.-J., Hagen H. 1856. Die im Bernstein befindlichen Neuropteren der Vorwelt [pp. 41-126]. *In:* Berendt G.C.

(ed), Die in Bernstein befindlichen organischen Reste der Vorwelt, gesammelt und in Verbindung mit Mehreren herausgegeben, 2. Band, 2. Abtheilung. *Nicolaische Buchhandlung, Berlin,* 2 + 126 pp.

Poda N. 1761. Insecta musei Graecensis, quae in ordines, genera et species juxta systema naturae Caroli Linnaei digessit. *Hoeredes Widmanstadii, Graecii*, 127 pp.

Puthz V. 1973a. Eintagsfliegen (Ephemeroptera) aus Südamerika. *Opuscula Zoologica Budapest* 12(1-2): 91-97.

Puthz V. 1973b. Was ist *Baetis aurantiaca* Burmeister 1839 (Ephemeroptera, Insecta)? *Philippia* 1(5): 262-270.

Puthz V. 1973c. Zwei neue Synonyme in der Gattung *Epeorus* Eaton (Insecta, Ephemeroptera: Heptageniidae). Sur les Ephéméroptères du Muséum d'histoire naturelle de Genève. III. *Revue suisse de Zoologie* 80(2): 577-580.

Puthz V. 1975. Über einige europäische Heptageniiden (Insecta, Ephemeroptera). Sur les Ephéméroptères du Muséum d'histoire naturelle de Genève. IV. *Revue suisse de Zoologie* 82(2): 321-333.

Puthz V. 1977. Bemerkungen über europäische *Siphlonurus*-Arten (Insecta, Ephemeroptera). *Reichenbachia (Staatliches Museum für Tierkunde in Dresden)* 16(16): 169-175.

Puthz V. 1978. Ephemeroptera [pp. 256-263]. *In:* Illies J. (ed.), Limnofauna Europaea. *Gustav Fischer Verlag, Stuttgart,* 532 pp.

Retzius A.I. 1783. Ephemera [pp. 56-57]. *In:* Caroli De Geer genera et species insectorum et generalissimi auctoris scriptis extraxit, digessit, latinae quand. partem reddidit, et terminologiam insectorum Linnaeanum addidit. *Siegfried Lebrecht Crusium, Lipsiae,* 220 pp.

Rogenhofer A. 1889. Josef Mann. Ein Nachruf. *Wiener Entomologische Zeitung* 8(7): 241-245.

Rostock M. 1888. Neuroptera germanica - Die Netzflügler Deutschlands. Die Netzflügler Deutschlands mit Berücksichtigung auch einiger ausserdeutscher Arten nach der analytischen Methode unter Mitwirkung von H. Kolbe bearbeitet. *Jahresbericht des Vereins für Naturkunde zu Zwickau* 18: 1-198.

Rutschmann S., Gattolliat J.L., Hughes S.J., Baez M., Sartori M., Monaghan M.T. 2014. Evolution and island endemism of morphologically cryptic *Baetis* and *Cloeon* species (Ephemeroptera, Baetidae) on the Canary Islands and Madeira. *Freshwater Biology* 59(12): 2516-2527.

Salles F.F., Soares E.D.G., Massariol F.C., Faria L.R.R. 2014. *Oligoneuria* Pictet: phylogenetic analysis and description of three new species from Brazil (Ephemeroptera: Oligoneuriidae). *Systematic Entomology* 39(2): 223-241.

Sartori M., Dethier M. 1985. Faune aquatique du Canton de Genève: II. Ephéméroptères (Insecta, Ephemeroptera). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* 58: 493-510.

Sartori M., Dethier M., De Sousa J. 1989. Faune aquatique de la région genevoise. III. Compléments aux Ephéméroptères (Insecta; Ephemeroptera). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* 62: 113-118.

Sartori M., Zabric D., Jann B. 1996. Trois espèces d'éphémères nouvelles pour la faune de Suisse (Ephemeroptera: Baetidae, Leptophlebiidae). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* 69: 135-139.

Saussure H. de 1879. Edouard Pictet. *Le Naturaliste. Journal des Échanges et des Nouvelles* 1: 134.

Savigny J.C. 1817. Description de l'Egypte, ou recueil des observations et des recherches qui ont été faites en Egypte pendant l'Expédition de l'armée française, publiée par ordre du gouvernement. Histoire naturelle. Planches, vol. I. *Imprimerie Royale, Paris,* 2 pls.

Say T. 1824. Zoology [pp. 253-278]. *In:* Keating W.H. (ed.), Narrative of an expedition to the source of St. Peter's River, Lake Winnepeck, Lake of the Woods, &c. &c. performed in the year 1823, by order of the Hon. J.C. Calhoun, Secretary of War, under the command of Stephen H. Long, Major U.S.T.E. Volume 2. comp. from the notes of Major Long, Messrs. Say, Keating, and Calhoun. *H.C. Carey & I. Lea, Philadelphia*, 444 pp.

Say T. 1839. Descriptions of new North American neuropterous insects, and observations on some already described. *Journal of the Academy of Natural Sciences of Philadelphia* 8: 9-46.

Schönemund E. 1930. Eintagsfliegen oder Ephemeroptera. *In:* Dahl F. (ed.), Die Tierwelt Deutschlands und der angrenzenden Meeresgebiete, 19 Teil. *Fischer Verlag, Jena,* 107 pp.

Schott H.W. 1822. Tagebücher des k.k. Gärtners, Hrn. H. Schott, in Brasilien. *In:* Schreibers K.v. (ed.), Nachrichten von den kaiserl. österreichischen Naturforschern in Brasilien und den Resultaten ihrer Betriebsamkeit, aus den Amtsrelationen der k. k. Gesandtschaft am Hofe von Rio Janeiro an das k. k. Ministerium der auswärtigen Angelegenheiten in Wien, aus den Berichten und Briefen der Naturforscher an den k. k. Hof-Naturalienkabinetsdirector, Herrn Karl v. Schreibers. II Heft, Anhang. *Joseph Georg Traßler, Brünn*, 116 pp.

Sowa R. 1971. Sur la taxonomie de *Rhithrogena semicolorata* (Curtis) et de quelques espèces voisines d'Europe continentale (Ephemeroptera: Heptageniidae). *Revue suisse de Zoologie* 77(4): 895-920.

Spieth H.T. 1940. The genus *Ephoron*. *The Canadian Entomologist* 72(6): 109-111.

Stephens J.F. 1836. Family III. - Ephemeridae, Leach. *Illustrations of British Entomology, Mandibulata* 6: 54-70, pl. 29.

Studemann D., Tomka I. 1987. Contribution to the study of European Ephemerellidae (Ephemeroptera). I. Completion of description of three endemic Iberian species. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* 60: 361-378.

Thomas A. 1968a. Quelques *Ecdyonurus* et *Rhithrogena* européens de la collection Navás (Ephemeroptera). *Annales de Limnologie* 4(2): 209-218.

Thomas A. 1968b. Sur la taxonomie de quelques espèces d'*Ecdyonurus* du Sud-Ouest de la France. *Annales de Limnologie* 4(1): 51-71.

Thomas A., Marie V., Brulin M. 2000. Corrections à la faune des Ephémères d'Europe occidentale: 2. *Epeorus assimilis* Eaton, 1885 est une espèce valide, distincte d'*E. sylvicolus* (Pictet, 1865) (Ephemeroptera, Heptageniidae). *Ephemera* 1(2): 85-91.

Turin P., Bilo M.F., Belfiore C. 1997. Primo reinvenimento in Italia di *Ametropus fragilis* Albarda 1878 (Ephemeroptera: Ametropodidae). *Lavori della Societa venetiana di Scienza Naturale* 22: 7-14.

Ulmer G. 1913. Ephemeriden aus Java, gesammelt von Edw. Jacobson. *Notes from the Leyden Museum* 35: 110-115.

Ulmer G. 1916. Ephemeropteren von Äquatorial-Afrika. *Archiv für Naturgeschichte* (Abteilung A) 81(7): 1-19.

Ulmer G. 1920a. Neue Ephemeropteren. *Archiv für Naturgeschichte* (Abteilung A) 11: 1-80.

Ulmer G. 1920b. Übersicht über die Gattungen der Ephemeropteren, nebst Bemerkungen über einzelne Arten. *Stettiner Entomologische Zeitung* 81: 97-144.

Ulmer G. 1921. Über einige Ephemeropteren-Typen älterer Autoren. *Archiv für Naturgeschichte* (Abteilung A) 87(6): 229-267.

Ulmer G. 1924a. Einige alte und neue Ephemeropteren. *Konowia* 3: 23-37.

Ulmer G. 1924b. Ephemeropteren von den Sunda-Inseln und den Philipinen. *Treubia* 6(1): 28-91.

Ulmer G. 1929. 6. Ordnung: Einstagfliegen, Ephemeroptera (Agnatha). *Die Tierwelt Mitteleuropas* 4(3): 1-43.

Vanzolini, P.E. 1993. As viagens de Johann Natterer do Brasil, 1817-1835. *Papeis Avulsos de Zoologia* 28(3): 17-60.

Walsh B.D. 1863. Observations on certain N. A. Neuroptera, by H. Hagen, M. D., of Koenigsberg, Prussia; translated from the original French ms., and published by permission of the author, with notes and descriptions of about twenty new N. A. species of Pseudoneuroptera. *Proceedings of the Entomological Society of Philadelphia* 2: 167-272.

Waltz R.D., McCafferty W.P., Thomas A. 1994. Systematics of *Alainites* n. gen., *Diphetor*, *Indobaetis*, *Nigrobaetis* n. stat., and *Takobia* n. stat. (Ephemeroptera, Baetidae). *Bulletin de la Société d'Histoire Naturelle de Toulouse* 130: 33-36.

Williams H.C., Ormerod S.J., Bruford M.W. 2006. Molecular systematics and phylogeography of the cryptic species complex *Baetis rhodani* (Ephemeroptera, Baetidae). *Molecular Phylogenetics and Evolution* 40(2): 370-382.

Zwick P. 1971. Die Plecopteren Pictets und Burmeisters, mit Angaben über weitere Arten (Insecta). *Revue suisse de Zoologie* 78(4): 1123-1194.

Revue suisse de Zoologie (September 2020) 127(2): 341-348 ISSN 0035-418

An annotated list of the Blattodea (Insecta) described by Henri de Saussure. Part 1: the Corydiidae

John Hollier[1*], Judith Marshall[2] & Frédéric Legendre[3]

1 *Muséum d'histoire naturelle de Genève, C.P. 6434, CH-1211 Genève 6, Switzerland.*
2 *Natural History Museum, Cromwell Road, London SW7 5BD, UK*
3 *Institut de Systématique, Evolution, Biodiversité (ISYEB), Muséum national d'Histoire naturelle, CNRS, Sorbonne Université, EPHE, Université des Antilles, CP 50, 57 rue Cuvier, F-75005 Paris, France*
* *Corresponding author: john.hollier@ville-ge.ch*

Abstract: Henri de Saussure described 32 species of cockroaches currently placed in the family Corydiidae, some of them in collaboration with Leo Zehntner. These species are listed alphabetically with an account of the type specimens in the Muséum d'histoire naturelle de Genève. The location of type specimens in other museums is given where known. The current binominal combination for each species is provided.

Keywords: Cockroaches - Geneva - London - Mexico.

INTRODUCTION

Henri de Saussure (1829-1905) was a prolific Genevan naturalist who described over three thousand species and many higher taxa (Hollier & Hollier, 2013). His interest in cockroaches began with his expedition to the Antilles and Mexico in 1854-1856 (Hollier & Hollier, 2012), and his first publications on the group were descriptions of species he had captured during his trip, or specimens sent to him by François Sumichrast, a Swiss naturalist who had accompanied Saussure on his exhibition but remained in Mexico when Saussure returned to Geneva. He returned to this insect group in the 1890s, partly working with the young Swiss entomologist Leo Zehntner (1864-1961) who acted as Saussure's assistant before going on to a distinguished career as a tropical applied entomologist (Hollier & Hollier, 2018). Saussure (alone and with Zehntner) is the author of 578 species level names in the Blattodea. The early descriptions are generally rudimentary and in most of his descriptions Saussure did not designate holotypes or even enumerate the number of specimens he had studied. He did not always state where the specimens were deposited.
Saussure described 32 species currently placed in the family Corydiidae. These are listed in the following.

ARANGEMENT AND FORMAT

The species are listed alphabetically. The format for each is:
specific epithet Author(s), publication: page [Original generic placement].
Type locality as given in the original description. Type series given in the original description.
Other information about provenance. Number of specimens in the MHNG. Specimen: "Label data" [format of label]. Following the recommendations of Ohl & Oswald (2004) the condition of each specimen is noted.
Location of material in the MHNG Blattodea collection.
The whereabouts of other type specimens (if known).
Currently valid binomen of taxon (following Beccaloni, 2014).

The following abbreviations are used:
CSF Cockroach Species Files Online (Beccaloni, 2014)
MCSN Museo Civico di Storia Naturale "Giacomo Doria", Genoa
MHNG Muséum d'histoire naturelle de Genève
MIZW Museum and Institute of Zoology, Warsaw
NHMUK Natural History Museum, London
SMF Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt
SMHS Stuttgart State Museum of Natural History

Manuscript accepted 02.07.2020
DOI: 10.35929/RSZ.0023

CATALOGUE

apacha Saussure, 1893: 296 [*Homoeogamia*]
Mexico; Chihuahua. Unspecified number of ♂.
The MHNG collection contains three specimens. A ♂ specimen (MHNG-ARTO-20574) with labels: "Chihuahua, Amer. Cent. Mr Corcelle" [handwritten on ruled white card]; "Chihuahua, Mr Corcelle" [handwritten on white paper]; "Homoeogamia apacha Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings spread. Most of both antennae, part of the tibia and the tarsi of both front legs, both middle legs, the right hind leg and the tibia and tarsi of the left hind leg are lost.
A ♂ specimen (MHNG-ARTO-20575) with labels: "Chihuahua, Amer. Cent. Mr Corcelle" [handwritten on ruled white card]; "Chihuahua, Mr Corcelle" [handwritten on white paper]; "Homoeogamia apache Sauss. ♂" [handwritten on green paper]; "Homoeogamia apacha Sauss., Cotype ♂, Muséum Genève" [handwritten on white card]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings spread. The end of the abdomen is detached and placed in a vial secured through the stopper on the original pin, and the right forewing is detached and glued to a card mount on the original pin. Most of both antennae, the left forewing, the left front leg, the tibia and tarsi of the right front leg, the tarsi of the right middle leg, the entire left middle and hind legs and the tarsi of the right hind leg are missing.
A ♀ specimen (MHNG-ARTO-20576) with labels: "Chihuahua, Amer. Cent. Mr Corcelle" [handwritten on ruled white card]; "Chihuahua, Mr Corcelle" [handwritten on white paper]; "Homoeogamia apacha Sauss. ♀ larva?" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, the right front tarsi are detached and glued to a card mount on the original pin. The tibia and tarsi of the right middle and hind legs and the entire left middle and hind legs are missing. Although this specimen was not explicitly mentioned in the original description (which was only as part of a key), the ♀ "Nympha(?)" is mentioned by Saussure & Zehntner (1894: 108) and the specimen is part of the type series. Box Blattodea 61.
Arenivaga apacha (Saussure, 1893)

azteca Saussure, 1862: 230 [*Corydia* (*Holocompsa*)]
Mexico calida. Unspecified series.
Saussure (1870) stated that he had three ♂ and six ♀ from the "Cordillère orientale". The MHNG collection contains eleven specimens, but four of them (MHNG-ARTO-20460 to MHNG-ARTO-20463) were sent from Costa Rica by Paul Biolley, a Swiss teacher who lived in Costa Rica from 1885 to 1908, and therefore cannot be part of the type series. The remaining specimens, all from Mexico, are probably part of the type series. A ♀ specimen (MHNG-ARTO-20453) with labels: "540 16, Vera Cruz t.c., Mexique, Vge. de Saussure" [handwritten on ruled white card]; "Holocompsa azteca Sss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings roughly folded. There is insect feeding damage to the thorax, and the left antenna, the left front leg, the tibia and tarsi of the left middle leg, the entire right middle leg and left hind leg and the tarsi of the right hind leg are missing.
A ♀ specimen (MHNG-ARTO-20454) with labels: "♀, Moyoapan, Mexique, env. Sumichrast" [handwritten on ruled white card]; "Holocompsa azteca Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings roughly folded. Both antennae, the right front leg and the tarsi of the left hind leg are lost.
A ♂ specimen (MHNG-ARTO-20455) with labels: "♂ Mexique, M H de Saussure" [handwritten on ruled white card]; "Holocompsa azteca Sss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. The ends of the antennae, both front legs, the tibia and tarsi of the left middle leg, the tarsi of the left hind leg and the entire right hind leg are lost.
A ♀ specimen (MHNG-ARTO-20456) with labels: "♀ Mexique, Sumichrast" [handwritten on ruled white card]; "Holocompsa azteca Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings roughly folded. The right antenna is missing.
A ♂ specimen (MHNG-ARTO-20457) with labels: "♂ Mexique, Sumichrast" [handwritten on ruled white card]; "Holocompsa azteca Sss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. The tips of the antennae and the right hind leg are missing.
A ♀ specimen (MHNG-ARTO-20458) with labels: "♀, Moyoapan, Mexique, env. Sumichrast" [handwritten on ruled white card]; "Holocompsa azteca Sss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings roughly folded. Most of both antennae, the tarsi of the right hind leg and two tarsal segments of the left hind leg are lost.
A ♀ specimen (MHNG-ARTO-20459) with labels: "♀, Orizaba, Mexique, Sumichrast" [handwritten on ruled white card]; "Holocompsa azteca Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. The head, the left front leg, the right middle leg and the right hind leg are missing. Box Blattodea 59.
There is a ♀ specimen in the NHMUK (BMNH(E)876462) with a data label "♀ Moyoapan, Mexique, env. Sumichrast" [handwritten on ruled white card] which is presumably a syntype although not labelled as such in their online database
Holocompsa azteca Saussure, 1862

azteca Saussure, 1893: 296 [*Homoeogamia*]
Mexico. Unspecified number of ♂ and ♀.
Saussure & Zehntner (1894) gave a full description of both sexes (in Saussure, 1893 the name only appears in a key) and stated that the provenance was Omilteme in Guerrero, leg. H. H. Smith. The MHNG collection contains eight specimens. A ♂ specimen (MHNG-ARTO-20481) with labels: "Omilteme, Guerrero, 8000ft, July, H.H. Smith" [printed on white card]; "Homoeogonia azteca Sauss. ♂" [handwritten on green paper]; "Pron. Figure!" [handwritten by Saussure on white card]; "Homoeogonia Azteca Sauss. Cotype ♂ Muséum Genève" handwritten on white card]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. Most of both antennae and the claws of the left hind leg are lost.
A ♀ specimen (MHNG-ARTO-20482) with labels: "Omilteme, Guerrero, 8000ft, July, H.H. Smith" [printed on white card]; "Homoeogonia azteca Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings roughly spread. The right hind leg is missing.
A ♀ specimen (MHNG-ARTO-20483) with labels: "Omilteme, Guerrero, 8000ft, July, H.H. Smith" [printed on white card]; "Homoeogonia azteca Sauss. ♂" [handwritten on green paper]; "figuré!" [handwritten by Saussure on white card]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. Most of the tight antenna and the last tarsal segment of the left hind leg are lost.
An immature specimen (MHNG-ARTO-20484) with labels: "Omilteme, Guerrero, 8000ft, July, H.H. Smith" [printed on white card]; "Homoeogonia azteca Sauss. larve" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. The ends of both antennae, the right front leg and the tarsi of the left hind leg are missing.
A ♀ specimen (MHNG-ARTO-20485) with labels: "Omilteme, Guerrero, 8000ft, July, H.H. Smith" [printed on white card]; "Homoeogonia azteca Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded.
An immature specimen (MHNG-ARTO-20486) with labels: "Omilteme, Guerrero, 8000ft, July, H.H. Smith" [printed on white card]; "Homoeogonia azteca Sauss. Larva ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. The right front leg is lost.
An immature specimen (MHNG-ARTO-20487) with labels: "Omilteme, Guerrero, 8000ft, July, H.H. Smith" [printed on white card]; "Homoeogonia azteca Sauss. Larva ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned.
An immature specimen (MHNG-ARTO-20488) with labels: "Omilteme, Guerrero, 8000ft, July, H.H. Smith" [printed on white card]; "Homoeogonia azteca Sauss. Larva ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. The ends of the antennae and the claws of the right middle and hind legs are missing. Box Blattodea 60.
A junior synonym of *Homoeogamia mexicana* Burmeister, 1838

azteca Saussure, 1868: 101 [*Paralatindia*]
Mexico. Unspecified number of ♂.
Saussure (1870) stated that he had thirteen ♂ and ten ♀ collected by Sumichrast under bark in the "région moyenne de la Cordillère orientale". The MHNG collection contains fifteen specimens. A ♂ specimen (MHNG-ARTO-20419) with labels: "♂ Moyo, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. The ends of the antennae, the right middle leg and both hind legs are missing, and there is insect feeding damage to the abdomen.
A ♀ specimen (MHNG-ARTO-20420) with labels: "♀ Mexique, env. Sumichrast" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. The ends of the antennae, the right front leg, the tarsi of the right middle leg and both hind legs are lost.
A ♀ specimen (MHNG-ARTO-20421) with labels: "larve ♀ Mexique, M. H de Saussure" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. The left hind leg is missing.
A ♀ specimen (MHNG-ARTO-20422) with labels: "♀ Moyo, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. The specimen has insect feeding damage to the head, and both front legs, the left middle leg, part of the femur, the tibia and tarsi of the right middle leg, the entire left hind leg and three tarsal segments of the right hind leg are missing.
A ♂ specimen (MHNG-ARTO-20423) with labels: "♂ Moyo, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. The ends of the antennae and both hind legs are missing.
A ♂ specimen (MHNG-ARTO-20424) with labels: "♂ Moyo, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. Both antennae, the tarsi of the left middle leg, both hind legs and the abdomen are missing.
An immature ♂ specimen (MHNG-ARTO-20425) with labels: "L ♂ Moyo, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♂"

[handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. The right antenna, left front leg and the tarsi of the left hind leg are lost.
A ♂ specimen (MHNG-ARTO-20426) with labels: "♂ Moyo, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♂" [handwritten on green paper]; "Prep. Bo 523" [handwritten on white card]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. The tarsi of the left hind leg and the entire right hind leg are missing. The abdomen is detached and dissected on a microscope slide preparation (MHNG-ARTO-20426a) stored in a box pinned into the insect box.
A ♂ specimen (MHNG-ARTO-20427) with labels: "♂ Mexique, env. Sumichrast" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings roughly folded.
A ♀ specimen (MHNG-ARTO-20428) with labels: "♀ Moyo, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned.
An immature ♂ specimen (MHNG-ARTO-20429) with labels: "L ♂ Moyo, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. Most of both antennae, the tarsi of the left front leg and the entire left middle leg are missing.
A ♀ specimen (MHNG-ARTO-20430) with labels: "♀ Moyo, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. Most of both antennae and both hind legs are lost.
An immature ♂ specimen (MHNG-ARTO-20431) with labels: "L ♂ Moyoap, Mexique, env. Sumichrast" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. Most of both antennae, the left front leg and the right middle and hind legs are missing.
A ♂ specimen (MHNG-ARTO-20430) with labels: "♂ Moyoap, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings roughly folded. There is insect feeding damage to the head thorax and abdomen. Both antennae, most of the tibia and the tarsi of the right front leg, the entire left middle leg and the tarsi of the right hind leg are missing.
A ♂ specimen (MHNG-ARTO-20431) with labels: "♂ Moyo, Mexique, env. S" [handwritten on ruled white card]; "Paralatindia azteca Sss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings roughly folded. Most of both antennae and the left hind leg are lost. Box Blattodea 59. The whereabouts of the other syntypes is unknown.
Paralatindia azteca Saussure, 1868

binotata Saussure & Zehntner, 1894: 110, pl. 3, fig. 32 [*Holocompsa*]
Guatemala; San Gerónimo (Champion). Unspecified number of ♀. Possibly conspecific ♂.
The MHNG contains one ♂ specimen (MHNG-ARTO-20464) with labels: "Amer. trop., var. ♂, M H de Saussure" [handwritten on ruled white card]; "Holocompsa binotata? ♂ Sauss." [handwritten on green paper]. The specimen is directly pinned. Both antennae, both front legs, the right middle leg and both hind legs are lost. The left forewing and right hindwing are detached and glued to a card mount secured on the original pin. This specimen is the ♂ mentioned in the original description, but because it was only considered to be probably conspecific cannot be considered a syntype. Box Blattodea 59.
There is a ♀ specimen in the NHMUK (BMNH(E)879466) with a data label "S. Geronimo, Guatemala, Champion" [printed on white card] and referred to as a syntype in their online database.
Holocompsa binotata Saussure & Zehntner, 1894

bolliana Saussure, 1893: 296 [*Homoeogamia*]
Texas. Unspecified number of ♂.
The MHNG collection has two specimens. A ♂ specimen (MHNG-ARTO-20572) with labels: "Dallas, Texas ♂" [Handwritten on ruled white card]; "Homoeogamia Bolliana ♂ Sauss." [handwritten on green paper]; Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings spread. The antennae and the tarsi of the left front leg are lost.
An immature ♂ specimen (MHNG-ARTO- 20573) with labels: "Dallas, Texas, l. ♂" [handwritten on ruled white card]; "Homoeogamia Bolliana larva ♂ Sauss." [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned and the tips of the antennae, the tarsi of the right front leg, the last tarsal segment of the right middle leg and the tarsi of the right hind leg are missing. There is no reason to suppose that these are not syntypes. Box Blattodea 61.
Arenivaga bolliana (Saussure, 1893)

brasiliana Saussure, 1864b: 228-229 [*Polyphaga* (*Homoeogamia*)]
Le Brésil. Unspecified number of juvenile ♂.
The MHNG contains 1 immature specimen (MHNG-ARTO-20490) with labels: "Nymphe, Brésil, M Sordet" [handwritten on ruled white card]; "Homoeogonia brasiliana Sauss." [handwritten on green paper]; "Homoeogonia brasiliana Saussure. Type, immature,

Muséum Genève" [handwritten on white card]; "Photographed in 1948. Polyphaga aegyptica (L.) juv. ♂ det A B Gurney" [handwritten on white card with "det A B Gurney" printed]; "Syntypus" [printed on red paper]. The specimen is directly pinned and the tarsi of the right hind leg and two tarsal segments of the left hind leg are lost. The type series was undefined and so this specimen should be regarded as a syntype. Box Blattodea 60.
Homeogamia brasiliana Saussure, 1864

capensis Saussure, 1893: 298, 301-302 [*Dyscologamia*]
Africa meridionalis (Mus. Genavense). Unspecified number of ♀.
The MHNG collection contains one ♀ specimen (MHNG-ARTO-20491) with labels: "620, 73 Cap b. sp., Mr Brady" and "Diese Etikette ist offensichtlich falsch. K. Princis 1952" [handwritten on opposite sides of a piece of ruled white card]; "Afriq. mér. Ouest de Zanzibar" [handwritten on white paper]; "Dyscologamia capensis Sss. ♀" [handwritten on red paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned and the right wings are partially spread. Most of the right antenna, the last tarsal segment of the left front leg, two tarsal segments of the left hind leg and the entire right hind leg are missing. The type series was undefined and so this specimen should be regarded as a syntype. Box Blattodea 60.
Ergaula capensis (Saussure, 1893)

cesticulata Saussure, 1893: 298-299 [*Dyscologamia*]
India orientalis: Singapore (Mus. Calcuttae). Unspecified number of ♀.
No specimens found in the MHNG collection. The whereabouts of the type specimen(s) is unknown.
A junior synonym of *Ergaula pilosa* (Walker, 1868)

cucullata Saussure & Zehntner, 1894: 111, pl. 5, fig. 9 [*Latindia*]
Guatemala; San Gerónimo (Champion). Unspecified number of ♂.
No specimens found in the MHNG collection.
There is a ♂ specimen in the NHMUK (BMNH(E)876600) with a data label "S. Geronimo, Guatemala, Champion" [printed on white card] and referred to as the holotype in their online database.
Compsodes cucullatus (Saussure & Zehntner, 1894)

delicatula Saussure & Zehntner,1894: 112, pl. 5, fig. 10 [*Latindia*]
Guatemala; Zapote (Champion). Unspecified series.
No specimens found in the MHNG collection.
There is a ♂ specimen in the NHMUK (BMNH(E)876601) with a data label "Zapote, Guatemala, G.C. Champion" [printed on white card] and referred to as the holotype in their online database.
Compsodes delicatulus (Saussure & Zehntner, 1894)

dohrniana Saussure, 1893: 309 [*Heterogamia*]
Sina septentrionalis. One ♂.
No specimens found in the MHNG collection. Much of Dohrn's collection is currently in the MIZW, but no specimens of this species were found there and the type material is apparently lost.
A junior synonym of *Eupolyphaga sinensis* (Walker, 1868)

dohrniana Saussure & Zehntner, 1894: 111, pl. 5, fig. 7 [*Latindia*]
Guatemala (coll. Dohrn). Unspecified number of ♀.
No specimens found in the MHNG collection. Much of Dohrn's collection is currently in the MIZW, but no specimens of this species were found there and the type material is apparently lost.
Latindia dohrniana Sussure & Zehntner, 1894

doriana Saussure, 1895: 84-85 [*Hemilatindia*]
Assab, 1879 (Marq. Doria; voyage de l'"Esploratore"). Unspecified number of ♂.
No specimens found in the MHNG collection. There is a ♂ specimen with corresponding data in the MCSN labelled as the holotype.
Tivia doriana (Saussure, 1895)

fenestrina Saussure 1864a: 324 [*Hypercompsa*]
Brasilia. Unspecified series.
Saussure (1864b) mentioned the ♀ and stated that the type series was in the SMF. No specimens found in the MHNG collection. The type series is presumably in the SMF although no database for their Blattodea collection exists.
Hypercompsa fenestrina Saussure, 1864

gestroiana Saussure, 1895: 81-82 [*Heterogamia*]
Boran Galla, Auata (mois de Mai, Bottego). Unspecified number of ♂.
No specimens found in the MHNG collection. There is a ♂ specimen with corresponding data in the MCSN labelled as the holotype.
Hemelytroblatta gestroiana (Saussure, 1895)

gueriniana Saussure, 1863: 140, fig. 7 [*Corydia*]
Les Indes orientales; Sangor dans l'intérieur des Indes. Unspecified number of ♂.
The MHNG collection contains one ♂ specimen (MHNG-ARTO-20470) with labels: "540 11, Sangor, Indes Or. ♂ coll. Guérin" [handwritten on ruled white card]; "Corydia nuptualis ♂ Gerst." [handwritten on yellow paper]; "Syntype of C. gueriniana Sauss. Hollier 2019" [handwritten on red paper]. This specimen was placed with three others in the MHNG collection under the name *Corydia nuptialis* but the name label pinned in the box has "nuptialis Gerst. (Gueriniana Sss.)" handwritten on it. The data label and the entry in the acquisitions register identify it as a syntype of *C. gueriniana*. The

specimen is directly pinned, with the wings spread. The left antenna, left front leg, four tarsal segments of the left middle leg and the last tarsal segment of the left hind leg are missing. Box Blattodea 59.
A junior synonym of *Therea nuptialis* (Gerstaecker, 1861)

hirsuta Saussure, 1899: 583 [*Heterogamia*]
Africa meridionalis. Unspecified number of ♀.
No specimens found in the MHNG collection. There is a specimen labelled as holotype in the SMHS.
A junior synonym of *Hemelytroblatta africana africana* (Linnaeus, 1758)

inca Saussure & Zehntner, 1894: 111-112, pl. 5, fig. 8 [*Latindia*]
Peru; Tarma. Unspecified number of ♂.
No specimens found in the MHNG collection. The whereabouts of the type specimen(s) is unknown.
Latindia inca Saussure & Zehntner, 1894

mancella Saussure & Zehntner, 1894: 114, pl. 5, fig. 6 [*Paralatindia*]
Peru; Tarma (Mus. Genavense). Unspecified number of ♂.
No specimens found in the MHNG collection. The whereabouts of the type specimen(s) is unknown.
Paralatindia mancella Saussure & Zehntner, 1894

mexicana Saussure, 1868: 100 [*Latindia*]
Mexico. Unspecified number of ♂ and ♀.
Saussure (1870) stated that he had seven ♂ and one ♀ captured by Sumichrast under the bark of pines near to Moyoapan. The MHNG collection contains five specimens. A ♂ specimen (MHNG-ARTO-20413) with labels: "♂ Mexique, env. Sumichrast" [handwritten on ruled white card]; "Latindia Mexicana Sauss." [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. Most of both antennae, the last tarsal segment of the right hind leg and the abdomen are missing. The right middle leg is detached and adheres to the hind legs.
A ♂ specimen (MHNG-ARTO-20414) with labels: "♂ Moyoapan, Mexique, env. Sumichrast" [handwritten on ruled white card]; "Latindia Mexicana Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings spread. Most of both antenna, the tarsi of the right middle leg and the tibia and tarsi of the right hind leg are lost.
A ♂ specimen (MHNG-ARTO-20415) with labels: "♂ Moyoap. Mexique, env. Sumichrast" [handwritten on ruled white card]; "Latindia Mexicana Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings roughly folded. The tip of the abdomen is detached and glued to a card mount on the original pin. The tips of the antennae, the right middle leg and both hind legs are lost.
A ♂ specimen (MHNG-ARTO-20416) with labels: "♂ Moyoap. Mexique, env. Sumichrast" [handwritten on ruled white card]; "Latindia Mexicana Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. Both antennae, the tarsi of the left hind leg and the abdomen are missing, with signs of insect feeding damage.
A ♂ specimen (MHNG-ARTO-20417) with labels: "Mexique, env. Sumichrast" [handwritten on ruled white card]; "Latindia Mexicana Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings roughly folded. The antennae, the right front wing, both hind wings, the tarsi of both front legs, both hind legs and the abdomen are lost. Box Blattodea 59. The whereabouts of the other syntypes is unknown.
Latindia mexicanus Saussure, 1868

nepalensis Saussure, 1893: 298, 300 [*Dyscologamia*]
India: Sikkim. Unspecified number of ♂.
No specimens found in the MHNG collection. The whereabouts of the type specimen(s) is unknown.
Ergaula nepalensis (Saussure, 1893)

ornata Saussure 1864a: 341 [*Melestoria*]
India; Bombay. Unspecified series.
The MHNG collection contains one ♂ specimen (MHNG-ARTO-20394) with labels: "Indes orient. ♂ M H de Saussure" [handwritten on ruled card]; Corydia ornata ♂ Sauss." [handwritten on yellow paper]; "Corydia westwoodi Gerst. Indes var." [handwritten on ruled white card]; "D'après une notice trouvée dans les manuscrits de Mr. de Saussure, cet insecte ne serait qu'une simple variété de C. westwoodi et vérifié par Gerstaecker. J'ai encore des doutes sur ce point ci." [handwritten by Jean Carl on a strip of white paper]; "Syntypus" [printed on red paper]. The specimen is pinned, with the wings folded. The left front leg, two tarsal segments of the right middle leg, the last tarsal segment of the left middle leg and the last tarsal segment of the right hind leg are lost. Because the type series was not defined, this specimen must be considered a syntype. Box Blattodea 59.
Eurycordia ornata (Saussure, 1864)

peruviana Saussure & Zehntner, 1894: 114, pl. 5, figs 11-14 [*Paralatindia*]
Peru; Tarma (Mus. Genavense). Unspecified number of ♂ and ♀.
The MHNG collection contains four specimens. A ♂ specimen (MHNG-ARTO-20434) with labels: "♂ Tarma, Perou, M H de Saussure" [handwritten on ruled white card]; "Paralatindia peruviana Sauss. ♂" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned, with the wings folded. The right hind wing and the tip of the abdomen are detached and glued to a card mount on the original pin.

Both antennae, the right front leg and the tarsi of the left middle leg are lost.
A ♀ specimen (MHNG-ARTO-20435) with labels: "♀ Tarma, Perou, M H de Saussure" [handwritten on ruled white card]; "4 40 Tarma Perou" [handwritten on ruled white card]; "Paralatindia peruviana Sauss. ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. Most of the left antenna is missing.
An immature ♀ (MHNG-ARTO-20436) with labels: "♀ larva, Perou, M H de Saussure" [handwritten on ruled white card]; "4 40 Perou central" [handwritten on white card]; "Paralatindia peruviana Sauss. Larva ♀" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. The tarsi of the right middle and hind legs are lost.
An immature ♂ (MHNG-ARTO-20437) with labels: "♂ larva, Perou, M H de Saussure" [handwritten on ruled white card]; "Paralatindia peruviana Sauss. Larva ♀ [sic]" [handwritten on green paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned. The right antenna, the last tarsal segment of the left middle leg, the entire right middle leg, the tarsi of the left hind leg and the entire right hind leg are lost. Although the larvae were not explicitly mentioned in the original description, they are clearly part of the type series. Box Blattodea 59.
Paralatindia peruviana Saussure & Zehntner, 1894

pilosella Saussure, 1895: 82-83 [*Heterogamia*]
Scioa; Let-Marefià (Antinori). Unspecified number of ♂.
No specimens found in the MHNG collection. There is a ♂ specimen with corresponding data in the MCSN labelled as the holotype.
Hemelytroblatta pilosella (Saussure, 1895)

pusilla Saussure & Zehntner, 1894: 112 [*Latindia*]
Peru; Tarma. Unspecified number of ♂.
No specimens found in the MHNG collection. The whereabouts of the type specimen(s) is unknown.
Latindia pusilla Saussure & Zehntner, 1894

sinensis Saussure, 1869: 282-283 [*Homoeogamia*]
Nord de la Chine; Pekin. Two ♂.
The MHNG collection contains one ♂ specimen (MHNG-ARTO-20468) with labels: "♂ Pekin, Chine, M. H de Saussure" [handwritten on ruled white card]; "Heterogamia sinensis Sauss. ♂" [handwritten on yellow paper]; Heterog. sinensis Sauss." [handwritten on blue paper]; "Syntypus" [printed on red paper]. The specimen is directly pinned with the left wings spread and the right wings folded. There is insect feeding damage to the head, and the left antenna, the last tarsal segment of the right middle leg, the last tarsal segment of the left hind leg and all of the tarsi of the right hind leg are missing. Box Blattodea 59. The whereabouts of the other syntype is unknown. This species is not listed in the CSF database. Kirby (1903: 379) considered *Polyphaga sinensis* (Saussure, 1869) to be a junior homonym of *P. sinensis* Walker, 1868 and proposed the replacement name *P. limbata*.
Replaced by *Eupolyphaga limbata* (Kirby, 1903)

syriaca Saussure, 1864a: 346 [*Polyphaga*]
Syria. Unspecified number of ♂.
There is one ♂ specimen in the MHNG collection (MHNG-ARTO-20595) with labels: "Syrie, ♂" [handwritten on ruled white card]; "Arenivaga Africana Africana (L.)" [handwritten on blue paper]: "Possible syntype of P. syriaca Saussure Hollier 2019" [handwritten on red paper]. The specimen is directly pinned, with the wings folded. There is insect feeding damage to the base of the abdomen and the femur of the left hind leg. Four tarsal segments of the left front leg and the entire right hind leg are missing. This specimen was placed with many others in the MHNG collection under the name *Arenivaga africana africana* (L.). The only other ♂ among them has a data label with an acquisition number showing that it entered the collection as "Heterogamia ursina Burm." from the collection of Guérin-Méneville. The very simple data label of specimen MHNG-ARTO-20595 suggests that it may be a syntype of *Polyphaga syriaca* Saussure. Box Blattodea 61.
A junior synonym of *Hemelytroblatta africana africana* (Linnaeus, 1758)

tamerlana Saussure, 1893: 316 [*Anisogamia*]
Turcomania. Unspecified number of ♀.
The MHNG contains one ♀ specimen (MHNG-ARTO-20465) with labels: "Turkestan, M. König" [handwritten on ruled white card]; "Turkestan König" [handwritten on yellow paper]; "Anisogamia tamerlana ♀ Sauss." [handwritten on yellow paper]; "Anisogamia tamerlana Sss. [handwritten on blue paper]; "Syntypus" [printed on red paper]. Most of both antennae are missing. Because the type series was not defined, this specimen must be considered a syntype. Box Blattodea 59.
Anisogamia tamerlana Saussure, 1893

tolteca Saussure & Zehntner, 1894: 109, pl. 3, fig. 35 [*Holocompsa*]
Guatemala; Purula in Vera Paz (Champion). Unspecifed number of ♀ (one?).
No specimens found in the MHNG collection.
There is a ♀ specimen in the NHMUK (BMNH(E)876463) with a data label "Purula, Vera Paz, Champion" [printed on white card] and referred to as the holotype in their online database.
Holocompsa tolteca Saussure & Zehntner, 1894

tolteca Saussure & Zehntner, 1894: 113 [*Latindia*]
Mexico; Moyoapan (Mus. Genavense). One broken specimen.
The MHNG collection contains one ♀ specimen (MHNG-ARTO-20418) with labels: "♀ Moyoap.,

Mexique, env. Sumichrast" [handwritten on ruled white card; "Latindia tolteca Sauss." [handwritten on green paper], "Holotypus" [printed on red card]. The specimen is directly pinned, with the wings folded. The specimen has insect feeding damage, and the antennae, three tarsal segments of both front legs, the tibia and tarsi of both middle legs, all of both hind legs and the abdomen are missing. Box Blattodea 59.

A junior synonym of *Latindia mexicanus* Saussure, 1868

zapoteca Saussure & Zehntner 1894: 109, pl. 3 fig. 33 [*Holocompsa*]

Guatemala; Zapote (Champion). Unspecified number of ♂.

No specimens found in the MHNG collection.

There is a ♂ specimen in the NHMUK (BMNH(E) 876464) with a data label "Zapote, Guatemala, G.C. Champion" [printed on white card] and referred to as the holotype in their online database.

Holocompsa zapoteca Saussure & Zehntner, 1894

ACKNOWLEDGEMENTS

Thanks are due to Anita Hollier and Peter Schwendinger for comments on the manuscript. Special thanks are due to Emmanuelle Werlen for entering the MHNG specimens into the MHNG database. We are grateful to Ben Price for exporting data from the NHMUK database to facilitate searching, to Roberto Poggi for information about the holdings of the MCSN, to Joachim Holstein for information about the holdings of the SMNS, to Wolfgang Nässig for information about the holdings of the SMF and to David Szymroszczyk for information about the holdings of the MIZW.

REFERENCES

Beccaloni G.W. 2014. Cockroach Species File Online. Version 5.0/5.0. Available at: http://Cockroach.SpeciesFile.org (Accessed 14.vi.2020).

Burmeister H. 1838. Kakerlaken, Schaben. Blattina. [pp. 469-517]. *In*: Burmeister H. 1838. Handbuch der Entomologie Volume 2, Part 1. *Berlin, Reimer*, pp. 397-571.

Gerstaecker A. 1861. Ueber das Vorkommen von ausstülpbaren Hautanhängen am Hinterleibe an Schaben. *Archiv für Naturgeschichte* 27(1): 107-115.

Hollier A., Hollier J. 2012. Henri de Saussure's expedition to Mexico and the West Indies (1854-56). *Antenna* 36(4): 231-238.

Hollier A., Hollier J. 2013. A re-evaluation of the nineteenth-century naturalist Henri de Saussure. *Archives of Natural History* 40: 302-319.

Hollier J., Hollier A. 2018. Leo Zehntner, Swiss pioneer of tropical applied entomology. *Antenna* 42(2): 56-60.

Kirby W.F. 1903. Notes on Blattidae etc., with descriptions of new genera and species in the collection of the British Museum, South Kensington. No. III. *The Annals and Magazine of Natural History* 12: 373-381.

Linnaeus C. 1758. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentis synonymis, locis. 10th edition. *Holmiae, Laurentii Salvi,* 823 pp.

Ohl M., Oswald J.D. 2004. Annotated list of the primary type specimens of Megaloptera and Raphidioptera (Insecta, Neuropterida) in the Museum für Naturkunde der Humboldt-Universität zu Berlin. *Deutsche Entomologische Zeitschrift* (N.S.) 51: 87-96.

Saussure H. de 1862. Orthoptera nova Americana (Diagnoses praeliminares). *Revue et Magasin de Zoologie Pure et Appliquée* 14: 163-171, 227-234.

Saussure H. de 1863. Mélanges Orthoptérologiques I. Blattidae. *Mémoires de la Société de Physique et d'histoire naturelle de Genève* 17: 129-172.

Saussure H. de 1864a. Blattarum novarum species aliquot. *Revue et Magasin de Zoologie Pure et Appliquée* 16: 305-326, 341-348.

Saussure H. de 1864b. Orthoptères de l'Amérique moyenne. *Ramboz & Schuchardt, Genève*, 279 pp., 2 plates.

Saussure H. de 1868. Orthoptera species novae aliquot. *Revue et Magasin de Zoologie Pure et Appliquée* 20: 97-101, 354-357.

Saussure H. de 1869. Mélanges Orthoptérologiques Fascicule II. Blattides et Phasmides. *Mémoires de la Société de Physique et d'histoire naturelle de Genève* 20: 227-328.

Saussure H. de 1870. Famille des Blattides [pp. 1-123, plates 1-2]. *In*: Saussure H. de 1870-1874. *Mission Scientifique au Mexique et dans l'Amérique Centrale. Recherches Zoologiques* 6(1): 1-533, plates 1-8.

Saussure H. de 1893. Révision de la tribu des Hétérogamiens. *Revue suisse de Zoologie* 1: 289-318.

Saussure H. de 1895. Esplorazione del Giuba e dei suoi affluenti, compiuta dal Cap. V. Bottego durante gli anni 1892-93 sotto gli auspicii della Societa Geographica Italiana. Risultati Zoologici V. Ortotteri. *Annali del Museo Civico di Storia Naturale di Genova* 35: 67-93.

Saussure H. de 1899. Orthoptera [pp. 567-664]. *In*: Voeltzkow A. (ed.). Wissenschaftliche Ergebnisse der Reisen in Madagaskar und Ostafrika in den Jahren 1889-95. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft* 21: 1-664.

Saussure H. de, Zehntner L. 1894. Blattidae (part) [pp. 105-123]. *In*: Godman F.D., Salvin O. (eds). Biologia Centrali-Americana. Insecta Orthoptera (Orthoptera Genuina) Volume 1. *Porter, London* 458 pp, 22 plates.

Walker F. 1868. Catalogue of the specimen of Blattariae in the collection of the British Museum. *British Museum, London* 239 pp.

Revue suisse de Zoologie (September 2020) 127(2): 349-360 ISSN 0035-418

Linyphiid spiders collected by V. Mahnert in Kenya, with the description of a new genus and two new species (Arachnida: Araneae)

Andrei V. Tanasevitch

A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Leninsky prospekt 33, Moscow 119071, Russia. E-mail: tanasevitch@gmail.com

Abstract: A collection of spiders from Kenya, assembled by Prof. Volker Mahnert and deposited in the Natural History Museum of Geneva, contains 16 identifiable linyphiid species. Among of them a new genus and two new species were revealed: *Afrotrichona* gen. nov., with *Afrotrichona mahnerti* sp. nov. as the type species, and *Agyneta spinifera* sp. nov. Males of *Pelecopsis subflava* Russell-Smith & Jocqué, 1986, *Lepthyphantes* (s. str.) *buensis* Bosmans & Jocqué, 1983, and *Machadocara gongylioides* Miller, 1970 are illustrated and briefly redescribed. The latter two species, together with *Agyneta habra* (Locket, 1968), *Metalepthyphantes vicinus* Locket, 1968, *Microctenonyx subitaneus* (O. Pickard-Cambridge, 1875) and *P. pasteuri* (Berland in Fage & Simon, 1936), are reported for the Kenyan fauna for the first time. In addition, *A. spinifera* sp. nov. is also reported from Tanzania.

Keywords: Taxonomy - Afrotropics - fauna - species records.

INTRODUCTION

At present, the linyphiid fauna of the Afrotropical Region amounts to at least 422 species, 106 of them are recorded from Kenya (Caporiacco, 1947, 1949; Denis, 1950a, 1962; Holm, 1962, 1968, 1979; Bosmans, 1977, 1979; Jocque, 1984; Russell-Smith & Jocque, 1986; Scharff, 1989; etc.). Spider material collected by Prof. Volker Mahnert in Kenya, which is presented below, adds to the Kenyan spider list eight linyphiid species, two of them are described here as new to science.

MATERIAL AND METHODS

This paper is based on spider material collected by Volker Mahnert (1943-2018) in Kenya and kept at the Muséum d'histoire naturelle de Genève, Switzerland (MHNG) of which he was the director from 1989 to 2005 (Schwendinger, 2019). The MHNG field numbers are given in square brackets. Specimens preserved in 75% ethanol were studied using a MBS-9 stereomicroscope. A Levenhuk C-800 digital camera was used for taking some of the pictures. The chaetotaxy of Erigoninae is given in a formula, e.g., 1.1.1.1, which refers to the number of dorsal spines on tibiae I-IV. In Micronetinae the chaetotaxy is given in a different formula, e.g., Ti I: 2-1-1-0, which means that tibia I has two dorsal spines, one pro-, one retrolateral spine, and no ventral spine (the apical spines are disregarded). All measurements are given in mm. The sequence of leg segment measurements is as follows: femur + patella + tibia + metatarsus + tarsus. Scale lines in the figures correspond to 0.1 mm unless indicated otherwise. Figure numbers are shown above the corresponding scale lines, the length they represent is given below them. The terminology of copulatory organs mainly follows that of Merrett (1963) and that of authors mentioned in the abbreviations below.

Abbreviations

ARP anterior radical apophysis
DSA distal suprategular apophysis *sensu* Hormiga (2000)
E embolus
EP embolus proper *sensu* Saaristo (1971)
Fe femur
FG Fickert's gland
LC lamella characteristica *sensu* Kulczyński (1898)
MM median membrane *sensu* Helsdingen (1965)
Mt metatarsus
P paracymbium
PH pit-hook *sensu* Saaristo (1973)
PMP posterior median plate *sensu* Helsdingen *et al.* (1977)
R radix

Manuscript accepted 10.07.2020
DOI: 10.35929/RSZ.0024

T needle-shaped tooth
TA terminal apophysis *sensu* Helsdingen (1965)
TmI position of trichobothrium on metatarsus I
Ti tibia
TP tailpiece (= fusiform/worm-shaped proximal part of radix) *sensu* Crosby & Bishop (1925).

RESULTS

Genus *Afrotrichona* gen. nov.

Type species: *Afrotrichona mahnerti* sp. nov.

Etymology: The generic name is a combination of two words: "Afro", referring to the "*terra typica*", and a part of the generic name *Trichoncoides* (see taxonomic remarks below). The gender is feminine.

Diagnosis: The genus contains medium-sized erigonines (total length 1.90-2.25) characterized by the following combination of somatic and genitalic characters:

1) Carapace unmodified in both sexes (Figs 1-3), eyes normal, not enlarged, cephalic pits (= sulci) absent.
2) Chaetotaxy formula 1.1.1.1. Metatarsus IV without trichobothrium. TmI 0.29-0.32.
3) Palpal tibia modified (Figs 8, 10).
4) Paracymbium small, narrow, strongly curved and almost forming a loop (Fig. 8).
5) Distal suprategular apophysis moderately developed (Figs 8, 12).
6) Embolus twisted. Radix with an anterior process guiding and protecting embolus (Figs 8-9, 11).
7) Epigyne with a visor-shaped structure overhanging its cavity, lateral walls forming an arch (Figs 4-7, 13-15).

Taxonomic remarks: The new Afrotropical erigonine genus bears some resemblance to the Ancient Mediterranean *Trichoncoides* Denis, 1950b. Namely, the embolic division in *Afrotrichona mahnerti* sp. nov. is similar to that in *T. piscator* (Simon, 1884) and *T. striganovae* Tanasevitch & Piterkina, 2012 by the presence of an anterior radical process guiding and protecting the embolus (Figs 9, 11 cf. Tanasevitch & Piterkina, 2012: fig. 7). The presence of a "visor" in the epigyne of *A. mahnerti* sp. nov. makes it resemble the epigyne of *Trichoncoides* members (Figs 13-14 cf. Tanasevitch & Piterkina, 2012: figs 40-45). The new genus is clearly distinguished from *Trichoncoides* by the chaetotaxy formula (1.1.1.1 in *Afrotrichona* gen. nov. *versus* 2.2.1.1 in *Trichoncoides*), by the unmodified male carapace, i.e. absence of a special group of spines on its cephalic part, as well as by the absence of a median septum in the epigyne of females.

Species included: Only the type species.

Distribution: Kenya.

Afrotrichona mahnerti sp. nov.

Figs 1-15

Holotype: MHNG; male [sample KENYA-74/35]; KENYA, Kerio Valley, 1100 m a.s.l., under stones; 18.XI.1974; leg. V. Mahnert.

Paratypes: MHNG; 1 male, 3 females [sample KENYA-74/35], collected together with the holotype. – MHNG; 1 male [sample KENYA-74/36]; KENYA, Lake Baringo, environs of Lake Baringo Lodge, 980 m a.s.l., sifting in savannah at foot of trees; 18.XI.1974; leg. V. Mahnert.

Etymology: The new species is named in honour of the well-known arachnologist, entomologist and ichthyologist Prof. Volker Mahnert, the collector of the type material.

Description

Male paratype: Total length 2.25 (Fig. 1). Carapace unmodified, 0.80 long, 0.68 wide, pale brown, with a grey polygonal spot in its centre and with a narrow grey margin (Figs 1-2). Chelicerae 0.35 long, unmodified. Legs pale brown to brown. Leg I 2.54 long (0.75 + 0.23 + 0.63 + 0.55 + 0.38), IV 2.66 long (0.78 + 0.25 + 0.63 + 0.60 + 0.40). Chaetotaxy 1.1.1.1, spines 1.5-2 times as long as diameter of corresponding leg segment. Metatarsus IV without trichobothrium. TmI 0.32. Palp (Figs 8-12): tibia conical distally, with a dark tooth retrolaterally; paracymbium narrow, almost forming a loop; distal suprategular apophysis relatively short, spoon-shaped; radix large; anterior radical process flat, tapering and directed forward, slightly curved and partially guiding and covering embolus; embolus thin, twisted. Abdomen (Fig. 1) 1.53 long, 1.18 wide, dark grey, sparsely covered with long hairs.

Female paratype: Total length 1.90 (Fig. 3). Carapace unmodified, 0.73 long, 0.58 wide. Chelicerae unmodified, 0.30 long. Legs pale brown. Leg I 2.26 long (0.63 + 0.20 + 0.55 + 0.50 + 0.38), IV 2.49 long (0.75 + 0.20 + 0.63 + 0.53 + 0.38). TmI 0.29. Abdomen (Figs 3-5) 1.23 long, 0.90 wide, dark grey, sparsely covered with long hairs (not visible in Figs 3-5 due to camera limitations). Epigyne (Figs 4-7, 13-15): epigynal cavity shallow, its anterior part somewhat covered by a rounded "visor". Lateral walls forming an arch, tapering anteriorly. Posterior median plate as long as wide, its anterior edge with a wide and shallow invagination. Chaetotaxy as in male.

Distribution: Kenya.

Agyneta spinifera sp. nov.

Figs 16-26

Holotype: MHNG; male [sample KENYA-74/06]; KENYA, Lake Naivasha, 10 km from Fisherman's Camp, under bark and stones; 5.XI.1974; leg. V. Mahnert.

Paratypes: MHNG; 1 male [sample KENYA-74/38]; Laikipia County, near Mukutan source, sifting in bushes; 22.XI.1974; leg. V. Mahnert. – MHNG; 1 male; TANZANIA, Arusha; 5.II.1981; leg. Chr. Burckhardt.

Etymology: The specific epithet is a feminine noun in apposition referring to the needle-shaped tooth at the base of the embolus in the male.

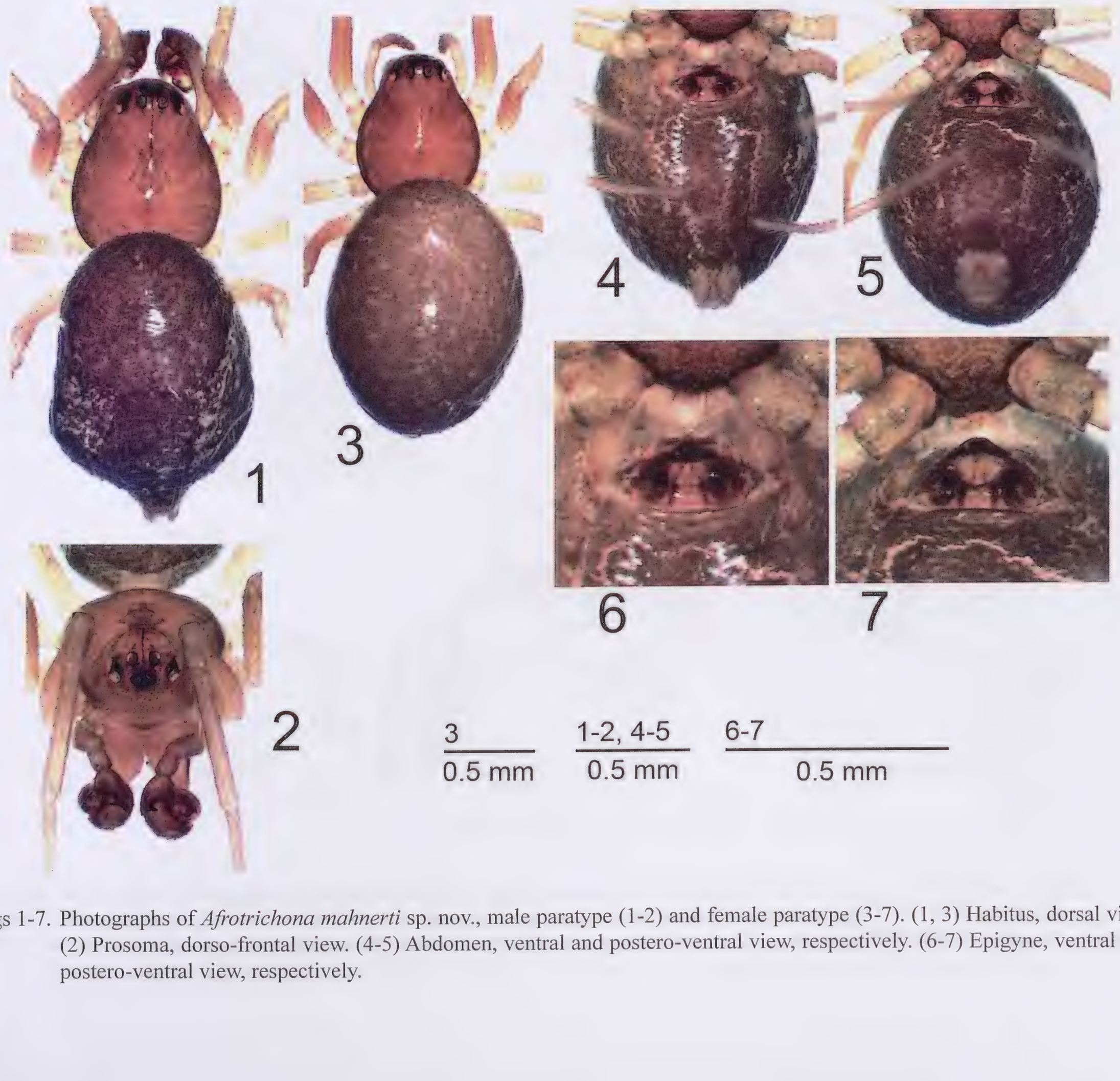
Description

Male holotype: Total length 1.65. Carapace slightly elongated, 0.75 long, 0.38 wide, brown, with a narrow grey margin. Chelicerae 0.28 long. Legs pale brown, femora with grey longitudinal darkening, tibiae darkened distally. Leg I 2.52 long (0.65 + 0.18 + 0.68 + 0.58 + 0.43), IV 2.52 long (0.68 + 0.18 + 0.68 + 0.63 + 0.35). Chaetotaxy 2.2.2.2, prolateral spine on TiI absent. Metatarsus IV without trichobothrium. TmI 0.22. Palp (Figs 16-26): tibia apically with two projections: a small, rounded prolateral one, and a short, wide, keel-shaped retrolateral one; cymbium with a small tubercle prolaterally; paracymbium relatively large, its posterior and anterior pockets poorly developed; distal suprategular apophysis with a small pit-hook; median membrane essentially reduced; lamella characteristica wide, apically notched, with small teeth/spikes on its upper edge and terminally; terminal apophysis long, widened proximally, tapered distally; embolus moderately bent, with a long, needle-shaped tooth at its base. Abdomen 0.90 long, 0.50 wide, dark grey.

Female: Unknown.

Taxonomic remarks: In the shape of its lamella characteristica the new species resembles *A. flandroyae* (Jocqué, 1985), known from Mt Karthala (1950-2300 m a.s.l.), Grande Comoros. *Agyneta spinifera* sp. nov. differs in the shape of the palpal tibia (Figs 18-21 cf. Jocque, 1985: fig. 28), in the shorter and slightly uncinate pit-hook on the distal suprategular apophysis (Fig. 22 cf. Jocque, 1985: figs 29, 31), as well as by the absence of a needle-shaped tooth at the base of the embolus.

Distribution: Known from Kenya and Tanzania.

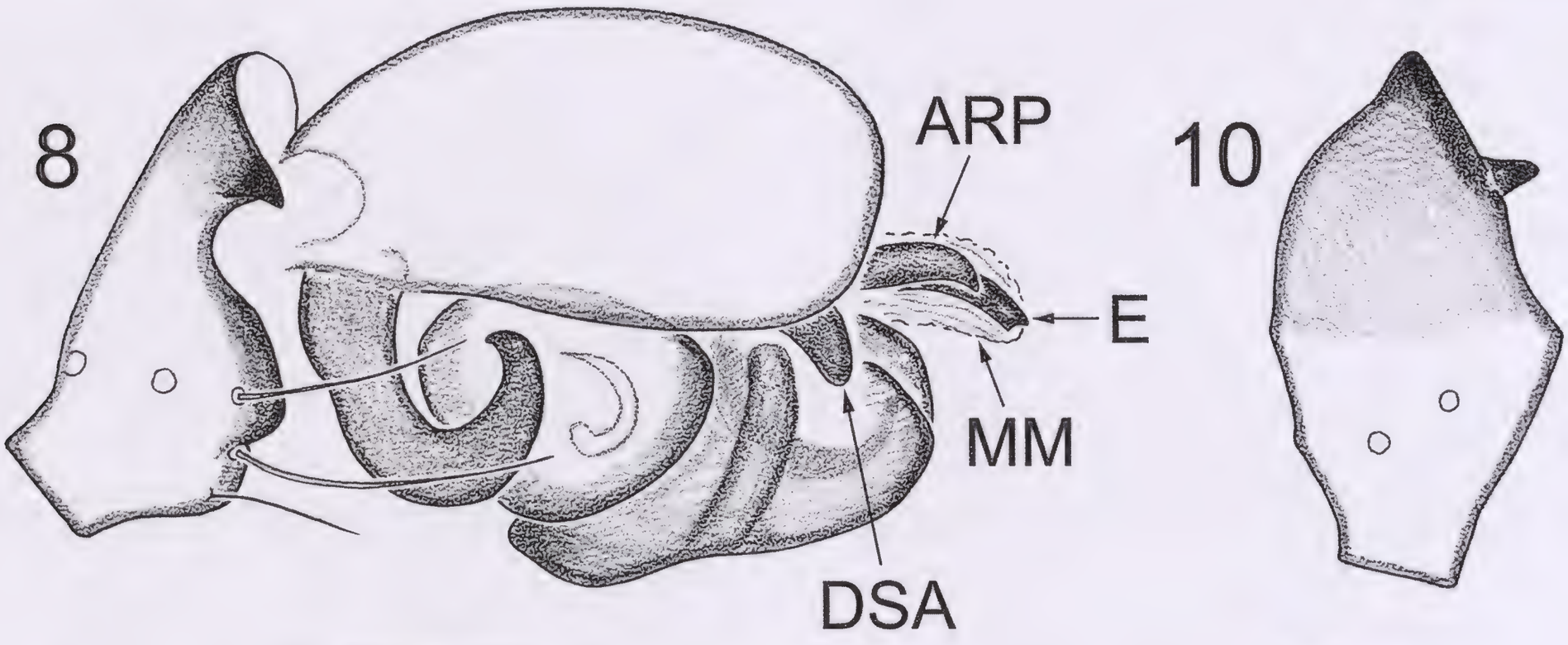


Figs 1-7. Photographs of *Afrotrichona mahnerti* sp. nov., male paratype (1-2) and female paratype (3-7). (1, 3) Habitus, dorsal view. (2) Prosoma, dorso-frontal view. (4-5) Abdomen, ventral and postero-ventral view, respectively. (6-7) Epigyne, ventral and postero-ventral view, respectively.

Agyneta habra **(Locket, 1968)**

Material examined: MHNG; 1 male [sample KENYA-74/01]; KENYA, Nairobi, sifting dead leaves in garden; 2.XI.1974; leg. V. Mahnert. – MHNG; 1 male, 1 female [KENYA-74/06]; 10 km from Fisherman's Camp, under bark and stones; 5.XI.1974; leg. V. Mahnert. – MHNG; 1 male [KENYA-74/38]; Laikipia, near Mukutan source, sifting in bushes; 22.XI.1974; leg. V. Mahnert.

Remarks: This species was hitherto known from Angola (Locket, 1968) and Nigeria (Locket & Russell-Smith, 1980). It is here recorded for the fauna of Kenya for the first time.



Figs 8-15. Details of male palp and epigyne structure of *Afrotrichona mahnerti* sp. nov., male paratype (8-12) and female paratype (13-15). (8-9) Right palp, retrolateral and ventro-prolateral view, respectively. (10) Palpal tibia, dorsal view. (11) Embolic division, ventro-prolateral view. (12) Distal suprategular apophysis, lateral view. (13-15) Epigyne, ventral, postero-ventral and lateral view, respectively.

Ceratocyba umbilicaris Holm, 1962

Material examined: MHNG; 1 male [sample KENYA-74/32]; KENYA, Mt Elgon National Park, ascent to Koitobos Peak, 2700 m a.s.l., sifting under bamboo; 15.XI.1974; leg. V. Mahnert.

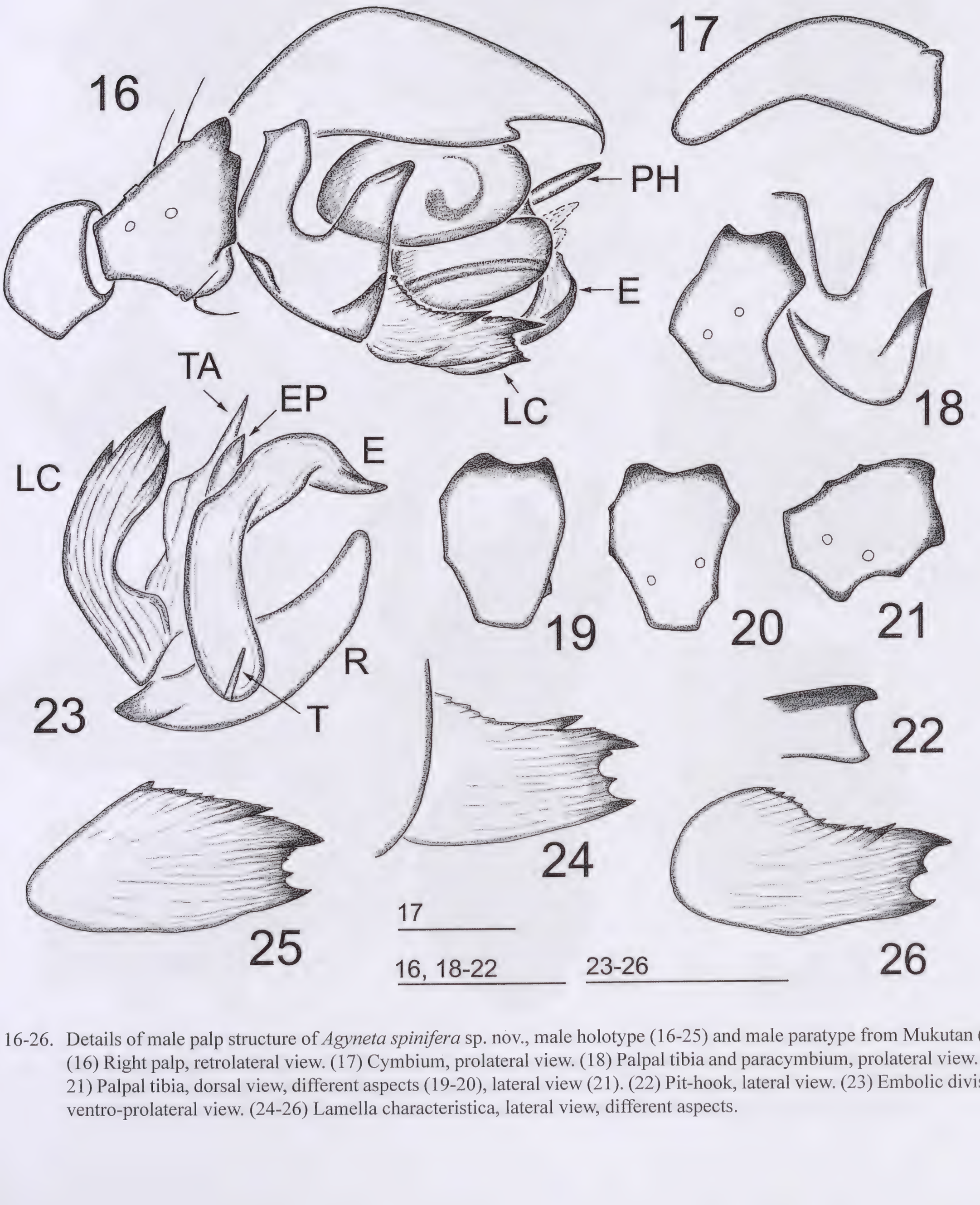
Remarks: This species was hitherto known from the same mountain, Mt Elgon, 2600 m a.s.l., Kenya (Holm, 1962).

Lepthyphantes buensis Bosmans & Jocqué, 1983

Figs 27-28, 36-40

Material examined: MHNG; 1 male, 2 females [sample KENYA-74/01]; KENYA, Nairobi, sifting dead leaves in garden; 2.XI.1974; leg. V. Mahnert.

Short re-description: *Male*. Total length 2.00 (Fig. 27). Carapace unmodified, 0.88 long, 0.75 wide, greyish pale brown, with narrow grey radial stripes. Chelicerae 0.33 long. Legs pale brown to yellow. Leg I 4.10 long (1.05 + 0.25 + 1.05 + 1.10 + 0.65), IV 3.63 long (1.00



Figs 16-26. Details of male palp structure of *Agyneta spinifera* sp. nov., male holotype (16-25) and male paratype from Mukutan (26). (16) Right palp, retrolateral view. (17) Cymbium, prolateral view. (18) Palpal tibia and paracymbium, prolateral view. (19-21) Palpal tibia, dorsal view, different aspects (19-20), lateral view (21). (22) Pit-hook, lateral view. (23) Embolic division, ventro-prolateral view. (24-26) Lamella characteristica, lateral view, different aspects.

+ 0.23 + 0.95 + 0.95 + 0.50). Chaetotaxy: FeI: 0-1-0-0, II-IV: 0-0-0-0; TiI: 2-1-1-0, TiII: 2-0-1-0. MtI-III: 1-0-0-0. TmI 0.11. Palp (Figs 36-40): cymbium with two projections basally; paracymbium relatively large, toothless; embolus large, slightly bent, carina reduced; terminal apophysis consisting of two parts of different shapes; lamella characteristica well-sclerotized, complex. Abdomen 1.13 long, 0.75 wide, dorsal pattern as in Fig. 27.

Female. Total length 2.25 (Fig. 28). Carapace 0.93 long, 0.75 wide. Chelicerae 0.45 long. Leg I 4.34 long (1.10 + 0.28 + 1.08 + 1.00 + 0.88), IV 3.98 (1.10 + 0.25 + 1.00 + 1.05 + 0.58). TmI 0.13. Abdomen 1.50 long, 1.13 wide, dorsal pattern as in Fig. 28. Epigyne as illustrated

Figs 27-35. Photographs of *Lepthyphantes* (s. str.) *buensis* Bosmans & Jocqué, 1983 (27-28), *Machadocara gongylioides* Miller, 1970 (29-31) and *Pelecopsis subflava* Russell-Smith & Jocqué, 1986 (32-35). (27-29, 32) Habitus, dorsal view. (30-31, 33-35) Prosoma, frontal (30), lateral (31, 34), dorsal (33) and fronto-lateral view (35).

by Bosmans & Jocqué (1983), Bosmans (1986). Body and leg coloration, and chaetotaxy as in male.

Distribution: This species was hitherto known from Cameroon only: Mt Cameroon, 1200-1800 m a.s.l. (Bosmans & Jocqué, 1983) and Mbam Massif, 1200 m a.s.l. (Bosmans, 1986). It is here recorded for the fauna of Kenya for the first time.

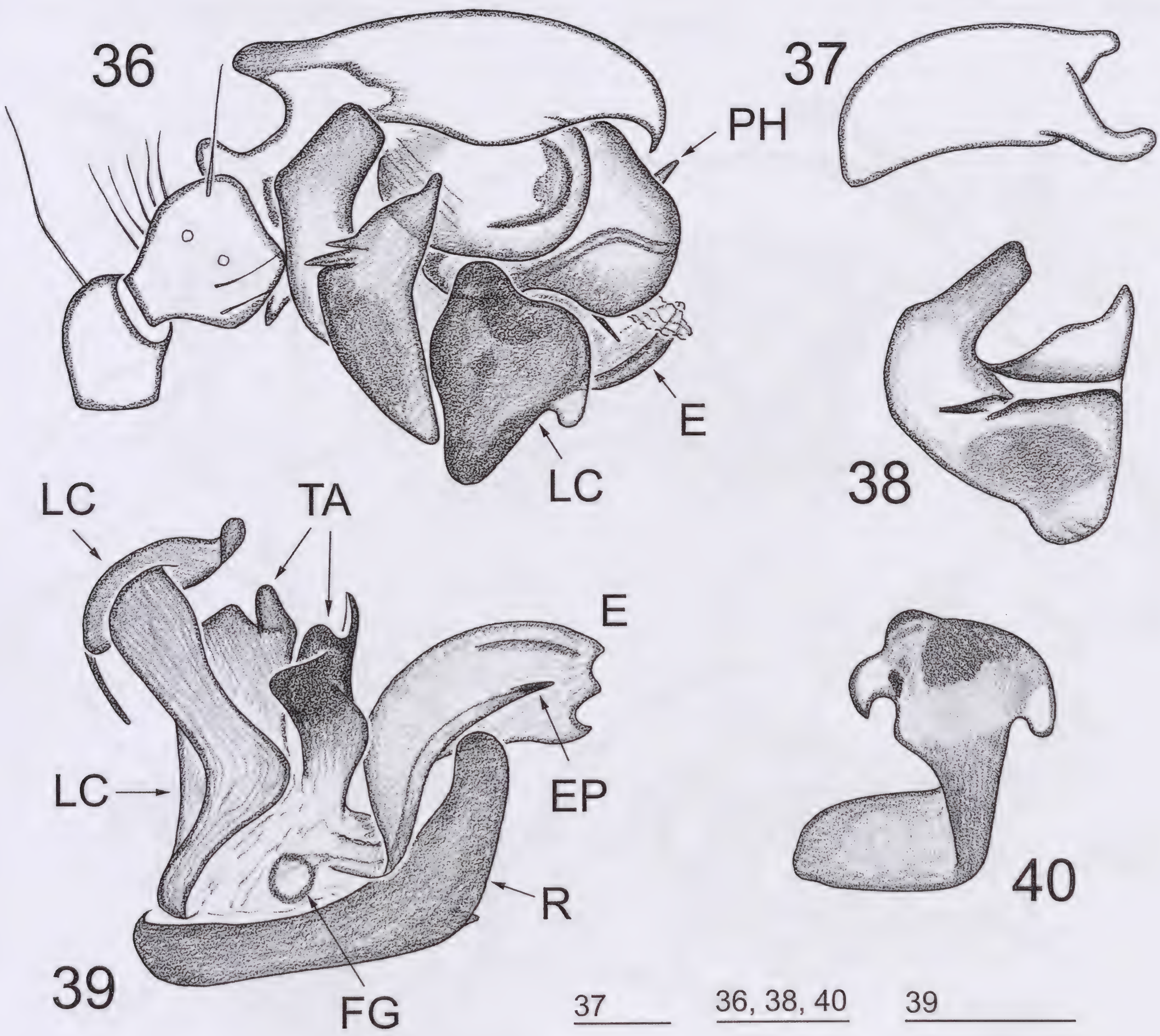
Taxonomic remarks: Judging from male genital morphology, namely the structure the embolus (see Saaristo & Tanasevitch, 1996b), the species belongs to *Lepthyphantes* sensu stricto, together with *L. cruentatus* Tanasevitch, 1987, *L. iranicus* Saaristo & Tanasevitch, 1996a, *L. leprosus* (Ohlert, 1867), *L. minutus* (Blackwall, 1833), *L. rossitsae* Dimitrov, 2018 and *L. simiensis* Bosmans, 1978.

***Machadocara gongylioides* Miller, 1970**

Figs 29-31, 41-44

Material examined: MHNG; 1 male [sample KENYA-74/07]; KENYA, Lake Naivasha, 5 km from Fisherman's Camp, under stones; 5.XI.1974; leg. V. Mahnert.

Short re-description: *Male*. Total length 2.05. Carapace modified as shown in Figs 29-31, 0.88 long, 0.70 wide, pale brown, with a narrow grey margin. Chelicerae 0.35 long. Legs relatively long and slender, pale brown. Leg I 3.86 long (1.05 + 0.25 + 0.95 + 0.98 + 0.63), IV 3.68 long (1.05 + 0.20 + 0.90 + 0.93 + 0.60). Chaetotaxy 1.1.1.1, spines 1-1.5 times diameters of corresponding leg segment. Metatarsus IV without trichobothrium. TmI 0.32. Palp (Figs 41-44): tibia



Figs 36-40. Details of male palp structure of *Lepthyphantes* (s. str.) *buensis* Bosmans & Jocqué, 1983. (36) Right palp, retrolateral view. (37) Cymbium, prolateral view. (38) Paracymbium, lateral view. (39) Embolic division, ventro-prolateral view. (40) Lamella characteristica, lateral view.

with a *Trichoncus*-like prolateral process, slightly widening distally; paracymbium extremely narrow; tegulum narrowing in its distal part; distal suprategular apophysis with a claw-shaped process; radix slender, its proximal part elongated, tailpiece-shaped; anterior radical process present, narrow, slightly curved distally; embolus thick, gradually tapering, forming a loop. Abdomen 1.20 long, 0.80 wide, grey.

Distribution: This species was hitherto known from Leopards Hill Cave, 1100 m a.s.l., Republic of Zambia (Miller, 1970). It is here recorded for the fauna of Kenya for the first time.

Mecynidis muthaiga Russell-Smith & Jocqué, 1986

Material examined: MHNG; 1 male, 1 female [sample KENYA-74/07]; KENYA, Lake Naivasha, 10 km from Fisherman's Camp, under stones; 5.XI.1974; leg. V. Mahnert.

Distribution: This species was hitherto known from Nairobi (Russell-Smith & Jocqué, 1986) and from Kinja, Lake Naivasha, 1950 m a.s.l., Kenya (Scharff, 1989).

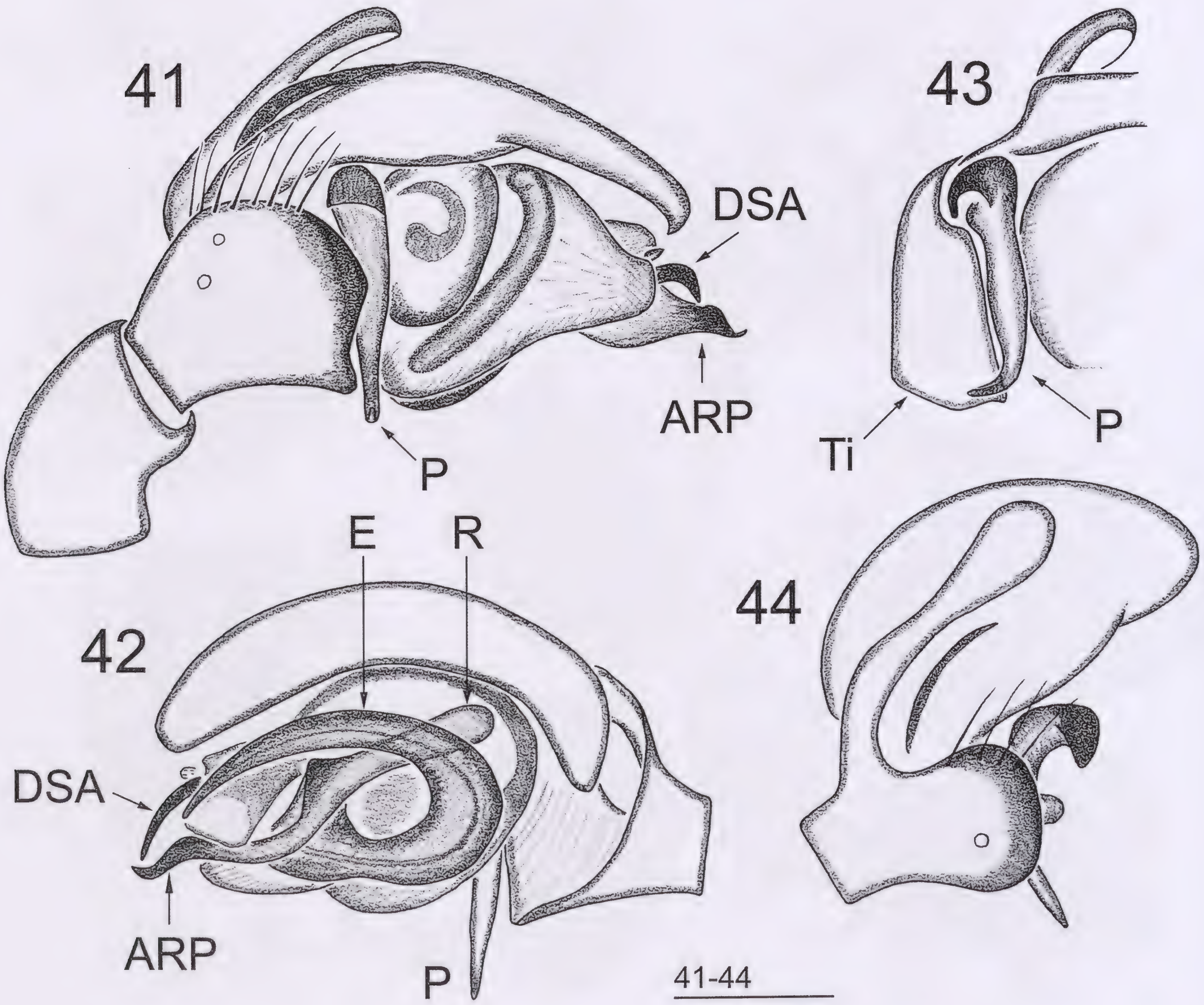
Metalepthyphantes vicinus Locket, 1968

Material examined: MHNG; 1 male [sample KENYA-74/44]; KENYA, environs of Nanyuki, 2000 m a.s.l., sifting in bushes; 24.XI.1974; leg. V. Mahnert.

Distribution: This species was hitherto known from Luimbale, 2300 m a.s.l., Angola (Locket, 1968). It is here recorded for the fauna of Kenya for the first time.

Microctenonyx subitaneus (O. Pickard-Cambridge, 1875)

Material examined: MHNG; 2 females [sample KENYA-74/01]; KENYA, Nairobi, sifting dead leaves



Figs 41-44. Details of male palp structure of *Machadocara gongylioides* Miller, 1970. (41-42) Right palp, retrolateral and prolateral view, respectively. (43) Proximal part of palpal organ, antero-retrolateral view. (44) Tibia, cymbium and paracymbium, dorsal view.

in garden; 2.XI.1974; leg. V. Mahnert. – MHNG; 1 male, 2 females [sample KENYA-74/08]; Lake Nakuru National Park, sifting dead leaves (*Acacia*); 6.XI.1974; leg. V. Mahnert.

Distribution: This species is here recorded for the fauna of Kenya for the first time. Previous records of natural occurrence are from Europe, Macaronesia, North Africa to Kyrgyzstan. It has been introduced to the USA, Argentina, South Africa, Australia and New Zealand (World Spider Catalog, 2020).

Pelecopsis alticola (Berland in Fage & Simon, 1936)

Material examined: MHNG; 1 male [sample KENYA-74/14]; KENYA, hill north of Kisumu, 1400 m a.s.l., sifting; 9.XI.1974; leg. V. Mahnert. – MHNG; 1 female [sample KENYA-74/42c], Mt Kenya, 2750 m a.s.l., Naromoruk Road, soil sample in bamboo (Berlese extraction); 23.XI.1974; leg. V. Mahnert.

Distribution: This species was hitherto known from Aberdare, Mt Kinangop, 3100-3400 m a.s.l., Kenya (Fage & Simon, 1936, Holm, 1962).

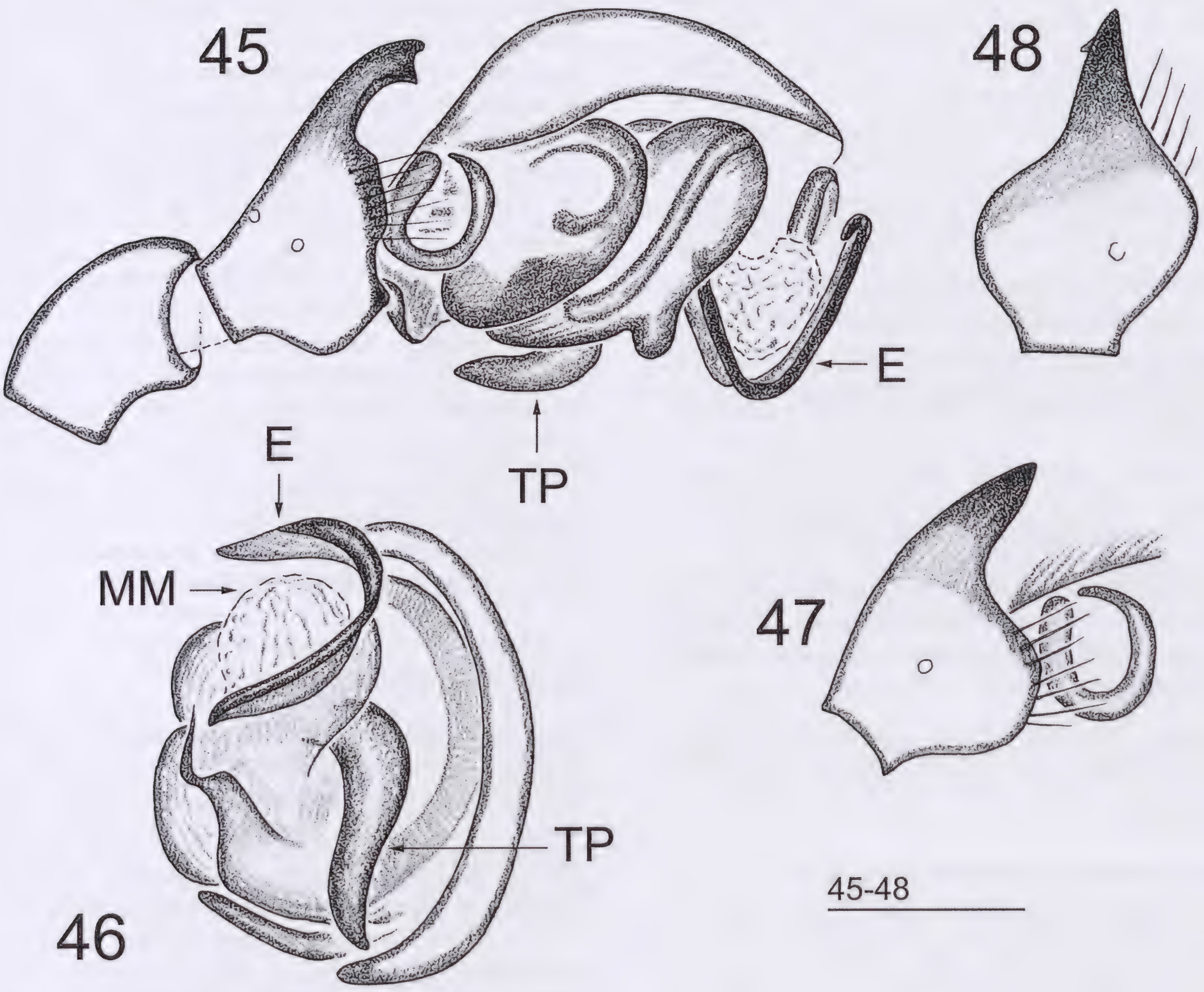
Pelecopsis alticola kenyensis (Holm, 1962)

Material examined: MHNG; 6 males, 12 females [sample KENYA-74/08]; KENYA, Lake Nakuru National Park, sifting dead leaves (*Acacia*); 6.XI.1974; leg. V. Mahnert.

Distribution: This species was hitherto known from Mt Kenya, 3920 m a.s.l., Kenya (Holm, 1962).

Pelecopsis pasteuri (Berland in Fage & Simon, 1936)

Material examined: MHNG; 1 male [sample KENYA-74/62]; KENYA, Taita Hills, Mwarungu (N Wundanyi), 1700 m a.s.l., in dead leaves; 3.XII.1974; leg. V. Mahnert.



Figs 45-48. Details of male palp structure of *Pelecopsis subflava* Russell-Smith & Jocqué, 1986. (45-46) Right palp, retrolateral and ventro-prolateral view, respectively. (47) Tibia and paracymbium, retrolateral and slightly proximal view. (48) Tibia, dorsal view.

Distribution: This species was hitherto known from Mt Kilimanjaro, 2700-3800 m a.s.l., Tanzania (Fage & Simon, 1936; Holm, 1962). It is here recorded for the fauna of Kenya for the first time.

Pelecopsis subflava Russell-Smith & Jocqué, 1986

Figs 32-35, 45-48

Material examined: MHNG; male [sample KENYA-74/06]; KENYA, Lake Naivasha, 10 km from Fisherman's Camp, under bark and stones; 5.XI.1974; leg. V. Mahnert.

Re-description: *Male*. Total length 1.28 (Fig. 32). Carapace 0.75 long, 0.60 wide, brown, with a grey margin. Cephalic part of carapace slightly elevated (Figs 33-35). Chelicerae 0.28 long, unmodified. Legs pale brown to brown. Leg I 1.66 long (0.45 + 0.18 + 0.38 + 0.35 + 0.30), IV 1.91 long (0.53 + 0.20 + 0.48 + 0.40 + 0.30). Chaetotaxy unclear: 0.0.0.0, or spines lost. Metatarsus IV without trichobothrium. TmI 0.54. Palp (Figs 45-48): tibia with a dorsal, elephant-trunk-shaped process; paracymbium narrow, long, forming a loop; tegulum with a knob ventrally; median membrane developed as a swollen, shapeless mass; embolic division large; radix fusiform, its tailpiece relatively long, slightly expanded in the middle; embolus flat, long, helical. Abdomen (Fig. 32) 1.00 long, 0.65 wide, dark grey, sparsely covered with long hairs.

Taxonomic remarks: This specimen slightly differs from the types described by Russell-Smith & Jocqué (1986) by its smaller size (1.28 *versus* 1.64), as well as by the curved tailpiece and its tapering proximal end.

Distribution: Known only from Nairobi and Lake Naivasha, Kenya (Russell-Smith & Jocqué, 1986 and present paper).

Pelecopsis reclinata (Holm, 1962)

Material examined: MHNG; 1 male [sample KENYA-74/27]; KENYA, Mt Elgon Forest Reserve, Mt Elgon, 2800 m a.s.l., sifting in primary forest near stream; 14.XI.1974; leg. V. Mahnert.

Distribution: This species was hitherto known from mountains of Kenya and Uganda, 2600-3760 m a.s.l. (Holm, 1962).

Tybaertiella convexa (Holm, 1962)

Material examined: MHNG; 1 male [sample KENYA-74/04], KENYA, Nairobi, soil sample in garden (Berlese extraction); 4.XI.1974; leg. V. Mahnert. – 1 male [sample KENYA-74/16]; Mission Kaimosi (NE de Kisumu), 1650 m a.s.l., sifting under *Juniperus*; 11.XI.1974; leg. V. Mahnert.

Distribution: The species is widespread in the Afrotropical Region (World Spider Catalog, 2020).

Tybaertiella krugeri (Simon, 1894)

Material examined: MHNG; 2 males [sample KENYA-74/06]; KENYA, 10 km from Fisherman's Camp, under bark and stones; 5.XI.1974; leg. V. Mahnert. – MHNG; 1 male [sample KENYA-74/09]; Lake Nakuru, near lake, under bark and under stones; 6.XI.1974, leg. V. Mahnert. – MHNG; 1 male [sample KENYA-74/38]; Laikipia, near Mukutan source, sifting in bushes; 22.XI.1974; leg. V. Mahnert.

Distribution: The species is widespread in the Afrotropical Region (World Spider Catalog, 2020).

CONCLUSION

Taking into account the new data, the spider fauna of Kenya currently counts no less than 114 linyphiid species, and at present it seems to be the best-known linyphiid fauna among the countries of the Afrotropical Region. Most of the species described or recorded from Kenya were collected in mountain territories, and they mainly belong to the subfamilies Erigoninae and Micronetinae (75 and 21 species, respectively). The representation of other subfamilies in this fauna is quite insignificant, i.e., Linyphiinae (8), Mynogleninae (6) and Ipainae (4 species).

The linyphiid fauna of Kenya is strongly regional. Only three of the currently known 114 species occur outside the Afrotropics: the European-Ancient Mediterranean *Microctenonyx subitaneus* is perhaps introduced, *Microlinyphia sterilis* (Pavesi, 1883) was reported (probably erroneously) also from China (Zhu & Shi, 1985), and *Erigone prominens* Bösenberg & Strand, 1906 is considered to be a cosmopolitan. The distributional ranges of the remaining species are currently limited to Kenya or the Afrotropical Region.

ACKNOWLEDGEMENTS

I am deeply grateful to Peter Schwendinger (MHNG) for providing the opportunity to work on the MHNG spider collections and for editing this paper. Thanks also go to Robert Bosmans (Gent, Belgium) who kindly reviewed the manuscript. This study was supported in part by the Presidium of the Russian Academy of Sciences, Program No. 41 "Biodiversity of natural systems and biological resources of Russia".

REFERENCES

Blackwall J. 1833. Characters of some undescribed genera and species of Araneidae. *London and Edinburgh Philosophical Magazine and Journal of Science* (3) 3: 104-112, 187-197, 344-352, 436-443.

Bösenberg W., Strand E. 1906. Japanische Spinnen. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft* 30: 93-422.

Bosmans R. 1977. Spiders of the subfamily Erigoninae from Mount Kenya. Scientific report of the Belgian Mt. Kenya Bio-Expedition, n° 3. *Revue zoologique africaine* 91: 449-472.

Bosmans R. 1978. Description of four new *Lepthyphantes* species from Africa, with a redescription of *L. biseriatus* Simon & Fage and *L. tropicalis* Tullgren. *Bulletin of the British Arachnological Society* 4: 258-274.

Bosmans R. 1979. Spiders of the subfamily Linyphiinae from Mount Kenya (Araneae - Linyphidae). Scientific report of the Belgian Mt. Kenya Bio-Expedition 1975, n° 17. *Revue zoologique africaine* 93: 53-100.

Bosmans R. 1986. Scientific report of the Belgian Cameroon Expeditions 1981 and 1983. 13. New species and new records of spiders of the family Linyphiidae (Araneae). *Revue zoologique africaine* 100: 171-204.

Bosmans R., Jocqué R. 1983. Scientific report of the Belgian Mount Cameroon Expedition 1981. No. 9. Family Linyphiidae (Araneae). *Revue zoologique africaine* 97: 581-617.

Caporiacco L. di 1947. Arachnida Africae Orientalis, a dominibus Kittenberger, Kovács et Bornemisza lecta, in Museo Nationali Hungarico servata. *Annales Historico-Naturales Musei Nationalis Hungarici* 40: 97-257.

Caporiacco L. di 1949. Aracnidi della colonia del Kenya raccolti da Toschi e Meneghetti negli anni 1944-1946. *Commentarii Pontificia Academia Scienciarum* 13: 309-492.

Crosby C.R., Bishop S.C. 1925. Studies in New York spiders; genera: *Ceratinella* and *Ceraticelus*. *New York State Museum Bulletin* 264: 1-71.

Denis J. 1950a. Spiders from East and Central African mountains collected by Dr. G. Salt. *Proceedings of the Zoological Society of London* 120: 497-502.

Denis J. 1950b. Araignées de France. III. Araignées de Camargue. *Revue française d'entomologie* 17: 62-78.

Denis J. 1962. Notes sur les érigonides. XX. Erigonides d'Afrique orientale avec quelques remarques sur les erigonides éthiopiens. *Revue de zoologie et de botanique africaines* 65: 169-203.

Dimitrov D. 2018. Description of *Lepthyphantes rossitsae* sp. n. from Turkey (Arachnida: Araneae: Linyphiidae). *Revue suisse de Zoologie* 125(2): 277-281.

Fage L., Simon E. 1936. Arachnida. III. Pedipalpi, Scorpiones, Solifuga et Araneae (1re partie). *In*: Mission scientifique de l'Omo. *Mémoires du Muséum d'Histoire Naturelle de Paris* 4: 293-340.

Helsdingen P.J. van 1965. Sexual behaviour of *Lepthyphantes leprosus* (Ohlert) (Araneida, Linyphiidae), with notes on the function of the genital organs. *Zoologische Mededelingen* 41: 15-42.

Helsdingen P.J. van, Thaler K., Deltshev C. 1977. The *tenuis* group of *Lepthyphantes* Menge (Araneae, Linyphiidae). *Tijdschrift voor Entomologie* 120: 1-54.

Holm Å. 1962. The spider fauna of the East African mountains. Part I: Fam. Erigonidae. *Zoologiska Bidrag från Uppsala* 35: 19-204.

Holm Å. 1968. Spiders of the families Erigonidae and Linyphiidae from East and Central Africa. *Annales, Musée Royal de l'Afrique Centrale, Sciences zoologiques* 171: 1-49

Holm Å. 1979. A taxonomic study of European and East African species of the genera *Pelecopsis* and *Trichopterna* (Araneae, Linyphiidae), with descriptions of a new genus and two new species of *Pelecopsis* from Kenya. *Zoologica Scripta* 8(1-4): 255-278.

Hormiga G. 2000. Higher level phylogenetics of erigonine spiders (Araneae, Linyphiidae, Erigoninae). *Smithsonian Contributions to Zoology* 609: 1-160.

Jocqué R. 1984. Notes on African Linyphiidae (Araneae) III. The genus *Tybaertiella*, with the description of a new species of *Pelecopsis*. *Bulletin of the British Arachnological Society* 6: 217-228.

Jocqué R. 1985. Linyphiidae (Araneae) from the Comoro Islands. *Revue zoologique africaine* 99: 197-230.

Kulczyński W. 1898. Symbola ad faunam aranearum Austriae inferioris cognoscendam. *Rozprawy i Sprawozdania z Posiedzen Wydzialu Matematyczno Przyrodniczego Akademji Umiejetnosci, Krakow* 36: 1-114.

Locket G.H. 1968. Spiders of the family Linyphiidae from Angola. *Publicações Culturais da Companhia de Diamantes de Angola* 71: 61-144.

Locket G.H., Russell-Smith A. 1980. Spiders of the family Linyphiidae from Nigeria. *Bulletin of the British Arachnological Society* 5: 54-90.

Merrett P. 1963. The palpus of male spiders of the family Linyphiidae. *Proceedings of the Zoological Society of London* 140: 347-467.

Miller F. 1970. Spinnenarten der Unterfamilie Micryphantinae und der Familie Theridiidae aus Angola. *Publicações Culturais da Companhia de Diamantes de Angola* 82: 75-166.

Ohlert E. 1867. Die Araneiden oder echten Spinnen der Provinz Preussen. *Wilhelm Engelmann, Leipzig*, 172 pp.

Pavesi P. 1883. Studi sugli aracnidi africani. III. Aracnidi del regno di Scioa e considerazioni sull'aracnofauna d'Abissinia. *Annali del Museo Civico di Storia Naturale di Genova* 20: 1-105.

Pickard-Cambridge O. 1875. On some new species of *Erigone*. *Proceedings of the Zoological Society of London* 43(2): 190-224, 323-335, pls XXII-XXIX, XLIV.

Russell-Smith A., Jocqué R. 1986. New species and records of Linyphiidae (Araneae) from Kenya. *Revue zoologique africaine* 99(4): 439-453.

Saaristo M.I. 1971. Revision of the genus *Maro* O. P.-Cambridge (Araneae, Linyphiidae). *Annales Zoologici Fennici* 8: 463-482.

Saaristo M.I. 1973. Taxonomical analysis of the type-species of *Agyneta*, *Anomalaria*, *Meioneta*, *Aprolagus*, and *Syedrula* (Araneae, Linyphiidae). *Annales Zoologici Fennici* 10: 451-466.

Saaristo M.I., Tanasevitch A.V. 1996a. Three new *Lepthyphantes* Menge, 1866, from Iran and Turkey (Aranei: Linyphiidae). *Arthropoda Selecta* 4(3/4): 61-64.

Saaristo M.I., Tanasevitch A.V. 1996b. Redelimitation of the subfamily Micronetinae Hull, 1920 and the genus *Lepthyphantes* Menge, 1866 with descriptions of some new genera (Aranei, Linyphiidae). *Berichte des Naturwissenschaftlich-Medizinischen Vereins in Innsbruck* 83: 163-186.

Scharff N. 1989. New species and records of afrotropical Linyphiidae (Araneae). *Bulletin of the British Arachnological Society* 8: 13-20.

Schwendinger P.J. 2019. Volker Mahnert, 3 December 1943 - 23 November 2018. *Revue suisse de Zoologie* 126(1): 1-16.

Simon E. 1884. Les arachnides de France, vol. 5, part 2. *Roret, Paris*, pp. 181-885, pl. 27.

Simon E. 1894. Histoire naturelle des araignées, vol. 1. *Roret, Paris*, pp. 489-760.

Tanasevitch A.V. 1987. The linyphiid spiders of the Caucasus, USSR (Arachnida: Araneae: Linyphiidae). *Senckenbergiana Biologica* 67: 297-383.

Tanasevitch A.V., Piterkina T.V. 2012. A new *Trichoncoides* Denis, 1950 (Aranei: Linyphiidae) from a semi-desert in the Caspian lowland. *Russian Entomological Journal* 21: 189-196.

World Spider Catalog 2020. World Spider Catalog, version 21.0. Natural History Museum Bern. Available at http://wsc.nmbe.ch (accessed in June 2020).

Zhu M.S., Shi J.G. 1985 (for 1983). Crop field spiders of Shanxi Province. *Agriculture Planning Committee of Shanxi Province*, 239 pp. [In Chinese]

Revue suisse de Zoologie (September 2020) 127(2): 361-366 ISSN 0035-418

A new species of *Diartiger* Sharp from Sichuan, China (Coleoptera: Staphylinidae: Pselaphinae)

Zi-Wei Yin[1] & Li He[2]

[1] *College of Life Sciences, Shanghai Normal University, 100 Guilin Road, Xuhui District, Shanghai 200234, China. E-mail: pselaphinae@gmail.com*

[2] *No.66, 5th Shuangcheng Road, Chenghua District, Chengdu 610051, China. E-mail: coleoptera@qq.com*

Abstract: *Diartiger wangzheni* Yin & He, sp. nov. is diagnosed, described, and illustrated based on a male specimen collected in Sichuan, southwestern China. The new species was found in association with *Lasius* ants (Hymenoptera: Formicidae) under a flat rock. An updated key to the males of *Diartiger* species known from China is provided.

Keywords: Taxonomy - Clavigeritae - myrmecophile - *Lasius* ant - key - Asia.

INTRODUCTION

The pselaphine genus *Diartiger* Sharp, 1883 of the obligately myrmecophilous supertribe Clavigeritae contains twelve species and eight subspecies distributed in Japan (5 spp. & 8 subspp.), Korea (1 sp. & 1 subsp. shared with Japan), China (6), and Vietnam (1) (Newton, 2020). Since Nomura (1997) described the first Chinese species from Kunming, Yunnan, five more congeners have been reported from Beijing, Anhui, Zhejiang, and Jiangxi (Yin *et al*., 2010; Yin & Li, 2013, 2014; Yin, 2018). The diversity of *Diartiger* in China seems to be underexplored probably due to the lack of specific collecting efforts in most areas (*i.e*., a majority of the species can be collected only by searching ant colonies nesting under rocks or in decomposing logs), especially in the tropical regions of the country.

In the present paper, a seventh *Diartiger* species of China is described from Sichuan and distinguished from its Chinese congeners.

MATERIAL AND METHODS

The type material of the new species described in this paper is deposited in the Insect Collection of Shanghai Normal University, Shanghai, China (SNUC). The text of the specimen label is quoted verbatim in quotation marks (‘’).

The genital parts were dissected and preserved in Euparal on a plastic slide that was placed on the same pin with the specimen; four individuals of host ants were glued on a broad card and pinned under the beetle. The habitus image was taken using a Canon 5D Mark III camera in conjunction with a Canon MP-E 65mm f/2.8 1-5X Macro Lens, and a Canon MT-24EX Macro Twin Lite Flash was used as the light source. Images of the morphological details were produced using a Canon G9 camera mounted to an Olympus CX31 microscope under reflected or transmitted light. Zerene Stacker (version 1.04) was used for image stacking. All images were optimized and grouped into plates using Adobe Photoshop CC 2018.

The abdominal tergites and sternites are numbered following Chandler (2001) in Arabic (starting from the first visible segment) and Roman (reflecting true morphological position) numerals, e.g., tergite 1 (IV), or sternite 1 (III).

TAXONOMY

Diartiger wangzheni Yin & He, sp. nov.

Figs 1-3

Type material: Holotype; ♂; CHINA, ‘China: Sichuan, Chengdu, Dujiangyan, Zipingpu Town, Ling-yan-guan-yin-shan Park, 31°1′48.48″N, 103°36′47.12″E, 1190 m, 2.V.2020, Z. Wang, L. He & C. Zhou leg., under rock with *Lasius* ants, 四川成都都江堰紫坪铺镇灵岩观音山景区’ (SNUC).

Type locality: Ling-yan-guan-yin-shan Park, Zipingpu Town, Dujiangyan, Chengdu, Sichuan, China.

Diagnosis: Male body length 2.2 mm. Anterior margin of clypeus roundly angulate at middle. Antennomeres 4 slightly more than 1.4 times as long as antennomeres 3.

Manuscript accepted 14.07.2020
DOI: 10.35929/RSZ.0025

Meso- and metatrochanters with large triangular spine; mesofemora angulate at middle of ventral margin. Aedeagus with small 'apical part'. Female unknown.

Description: Male. Body (Fig. 1A) length 2.2 mm; reddish brown. Head (Fig. 1B) longer than wide, length from anterior margin of clypeus to head base (excluding occipital constriction) 0.43 mm, width across eyes 0.29 mm; anterior margin of clypeus angulate, pointed at middle; each eye composed of about 20 facets; antennomeres 3 and 4 each much longer than antennomeres 1 and 2 (Fig. 2A); length of antennomeres 2-4 0.05, 0.23, 0.33 mm, respectively; antennomeres 4 slightly more than 1.4 times as long as antennomeres 3, broadening from base toward apex, apically truncate. Pronotum (Fig. 1B) subglobose, about as long as wide, length along midline 0.44 mm, maximum width

Fig 1. *Diartiger wangzheni* sp. nov. male. (A) Dorsal habitus (B) Head dorsum and pronotum. (C) Tergite 5 (VIII) and sternite 6 (VIII), showing black thickened setae at middle. Scale bars: 0.5 mm in A; 0.2 mm in B-C.

0.42 mm. Elytra (Fig. 1A) much wider than long, length along suture 0.58 mm, maximum width 0.84 mm; disc lacking linear microsculpture; with sub-triangular tufts of setae at posterolateral margins (Fig. 2B). Prosternum (Fig. 2E) roughly sculptured medially. Mesoventrite (Fig. 2E) with short intercoxal ridge. Metaventrite (Fig. 2E) convex, densely setose medially, lateral areas with distinct linear microsculpture. Mesotrochanters (Fig. 2C) with large triangular ventral spine, mesofemora (Fig. 2C) angulate on ventral margin at middle; metatrochanters (Fig. 2D) with distinct ventral spine slightly smaller than that of mesotrochanters. Abdomen large, wider than long, much wider than elytra, length along midline 0.75 mm, maximum width 0.91 mm; composite tergite broadly and deeply concave mediobasally, with tufts of curved trichomes

Fig 2. *Diartiger wangzheni* sp. nov. male. (A) Right antenna (B) Elytral apex and abdominal base, showing trichomes. (C) Right middle leg (D) Right hind leg (E) Prosternum and meso- and metaventrite. (F, G) Aedeagus, in lateral (F) and ventral (G) view. Scale bars: 0.2 mm.

at basolateral region (Fig. 2B), first pair of paratergites with curved trichome (Fig. 2B). Sternite 6 (VIII) with bunch of short, thick setae at middle. Aedeagus (Fig. 2F, G) moderately sclerotized, length 0.46 mm; median lobe at apex narrowing and strongly curved ventrad, with membranous part at dorso-apical side.
Female. Unknown.

Comparative notes: The males of the new species can be readily separated from those of all congeners by the relatively stouter habitus, the unique spination of the legs, and the configuration of the aedeagus. An identification key to males, updated from Yin & Li (2014), is provided below to aid in the discriminations of the Chinese species:

Biology: The male was found with *Lasius* ants (Fig. 3C) under a flat rock (Fig. 3B) in a mixed forest (Fig. 3A).

Distribution: China (Sichuan).

Etymology: The new species is named after Zhen Wang, one of the collectors of the holotype.

ACKNOWLEDGMENTS

LH thanks Chao Zhou and Zhen Wang (both Chengdu, China) for a pleasure company during the field trip. Two anonymous reviewers provided helpful comments on the draft manuscript. The present study was supported by the National Natural Science Foundation of China (No. 31872965), and the 'Phosphor' Science Foundation, Shanghai Municipal Science and Technology Commission, China (19QA1406600) awarded to ZWY.

1A Dorsal surface of head and pronotum with sparse, thick, and suberect setae (Yin *et al*., 2010: fig. 1). Mesotrochanters lacking spine (Yin *et al*., 2010: fig. 4); mesofemora with large, curved projection. (Zhejiang) ..... ***D. songxiaobini*** (Yin & Li, 2010)

1B Dorsal surface of head and pronotum with dense, fine setae. Mesotrochanters with spine of various forms 2

2A Fourth antennomeres more than twice as long as third antennomeres 3

2B Fourth antennomeres less than twice as long as third antennomeres 4

3A Mesofemora with sharp ventral spine at base (Yin & Li, 2013: fig. 2C); mesotibiae with triangular tubercle near middle (Yin & Li, 2013: fig. 2C); mesal margin of metatibiae distinctly protuberant at basal 1/4, then strongly curved, curved area with very dense setae (Yin & Li, 2013: fig. 2D). (Anhui) ..... ***D. dentatus*** Yin & Li, 2013

3B Ventral margin of mesofemora regularly protuberant at base, lacking spines (Yin & Li, 2014: fig. 2C); mesotibiae lacking tubercles near middle (Yin & Li, 2014: Fig. 2C); mesal margin of metatibiae moderately protuberant at basal 1/4, then moderately curved, curved area with relatively sparse setae (Yin & Li, 2014: Fig. 2D). (Zhejiang) ..... ***D. zhejiangensis*** Yin & Li, 2014

4A Mesofemora angularly protuberant at middle (Fig. 2C). Sternite 6 (VIII) with bunch of short, thick setae at middle (Fig. 1C) (Sichuan) ..... ***D. wangzheni*** Yin & He, sp. nov.

4B Mesofemora smooth at middle, lacking protuberances nor tubercles or spines. Sternite 6 (VIII) lacking bunch of short, thick setae at middle 5

5A Anterior margin of clypeus distinctly angulate (Yin & Li, 2013: fig. 1B) (Anhui) ..... ***D. yaoluopingensis*** Yin & Li, 2013

5B Anterior margin of clypeus approximately rounded 6

6A Mesotrochanters with large, long, and blunt ventral projection (Nomura, 1997: fig. 6km., km-a). Median lobe of aedeagus with large 'apical part', area near apex lacking dense setae (Nomura, 1997: fig. 12km.). (Yunnan) ..... ***D. kunmingensis*** Nomura, 1997

6B Mesotrochanters with large and sharp ventral spine (Yin, 2018: fig. 2D). Median lobe of aedeagus with small 'apical part', area near apex with dense setae (Yin, 2018: fig. 2F, G) (Beijing) ..... ***D. beijingensis*** Yin, 2018

Fig. 3. Collection environment (A), habitat (B), and a living adult *in situ* (C) of *Diartiger wangzheni* sp. nov.

REFERENCES

Chandler D. S. 2001. Biology, morphology, and systematics of the ant-like litter beetles of Australia (Coleoptera: Staphylinidae: Pselaphinae). *Memoirs on Entomology International* 15: 1-560.

Newton A. F. 2020. StaphBase: Staphyliniformia world catalog database (version Nov 2018). *In*: Roskov Y., Ower G., Orrell T., Nicolson D., Bailly N., Kirk P. M., Bourgoin T., DeWalt R. E., Decock W., van Nieukerken E., Zarucchi J., Penev L. (eds), Species 2000 & ITIS Catalogue of Life, 2020-02-24. Digital resource at www.catalogueoflife.org/col. Species 2000 : Naturalis, Leiden, the Netherlands. (last accessed 2020-05-15)

Nomura S. 1997. A systematic revision of the clavigerine genus *Diartiger* Sharp from East Asia (Coleoptera, Staphylinidae, Pselaphinae). *Esakia* 37: 77-110.

Sharp D. 1883. Revision of the Pselaphidae of Japan. *Transactions of the Entomological Society of London* 1883: 291-331.

Yin Z.-W. 2018. New species and records of myrmecophilous Pselaphinae (Coleoptera: Staphylinidae) from China. *Coleopterists Bulletin* 72(1): 161-165.

Yin Z.-W., Li L.-Z. 2010. *Microdiartiger songxiaobini* sp. nov. *In*: Yin Z.-W., Li. L.-Z., Zhao M.-J. 2010. Contributions to the knowledge of the myrmecophilous pselaphines (Coleoptera, Staphylinidae, Pselaphinae) from China. II. *Microdiartiger* (Pselaphinae, Clavigeritae) new to China, with description of a new species. *Sociobiology* 56(3): 639.

Yin Z.-W., Li L.-Z. 2013. Notes on synonymy of *Diartiger* Sharp with *Microdiartiger* Sawada (Coleoptera: Staphylinidae: Pselaphinae), with description of two new species from East China. *Zootaxa* 3717(3): 369-376.

Yin Z.-W., Li L.-Z. 2014. A new species of *Diartiger* Sharp (Staphylinidae, Pselaphinae, Clavigeritae) from the Fengyangshan - Baishanzu Nature Reserve, East China. *ZooKeys* 419: 129-135.

Yin Z.-W., L.-Z. Li., M.-J. Zhao. 2010. Contributions to the knowledge of the myrmecophilous pselaphines (Coleoptera, Staphylinidae, Pselaphinae) from China. II. *Microdiartiger* (Pselaphinae, Clavigeritae) new to China, with description of a new species. *Sociobiology* 56(3): 637-643.

Revue suisse de Zoologie (September 2020) 127(2): 367-376 ISSN 0035-418

Plumularia roxanae, a new epiphytic hydroid (Cnidaria: Hydrozoa: Plumulariidae) from the Indo-Pacific

Horia R. Galea

Hydrozoan Research Laboratory, 405 Chemin Les Gatiers, F-83170 Tourves, France. E-Mail: horia.galea@gmail.com

Abstract: A new epiphytic, small-sized species of *Plumularia* Lamarck, 1816, *P. roxanae* sp. nov., is described based on fertile material from Bali, Indonesia. Its deep hydrothecae are characteristically narrowed distally through a distinctive hypertrophy of the free portion of their adaxial wall. Its minute gonothecae, however, are comparable in shape and size to those of the well-known, circumtropical *P. floridana* Nutting, 1900.

Keywords: Taxonomy - new species.

INTRODUCTION

The highly speciose, circumglobal, ecologically diverse genus *Plumularia* Lamarck, 1816 comprises feather-shaped hydroids ranging in form from small, pinnate colonies with monosiphonic, unbranched stems to large structures composed of repeatedly branched, occasionally fascicled stems (Bouillon *et al.*, 2006). As noted by Schuchert (2013a, b), its taxonomy proves occasionally challenging, due to an important intraspecific variation (e.g. internode length, shape of hydro- and gonothecae) and a limited availability of diagnostic morphological characters. Although new species are still created based on infertile specimens (Watson, 2012), thus adding to the actual difficulties in the identification of numerous poorly-described nominal taxa erected by earlier authors (e.g. Mulder & Trebilcock 1911, 1914, 1915; Fraser 1938a, b, c, 1948), a small, epiphytic *Plumularia* with distinctive hydro- and gonothecae is described from material collected recently from Bali, Indonesia.

MATERIAL AND METHODS

Hydroid-covered algae freshly washed ashore were collected by hand during an ebb tide, and fixed immediately in 4% buffered formalin in seawater. The material was subsequently sorted in the laboratory and observations were made according to the methods described by Galea (2007, 2008). Holo- and paratype specimens are deposited in the invertebrate collection of the Muséum d'histoire naturelle of Geneva, Switzerland.

RESULTS

Plumularia roxanae sp. nov.

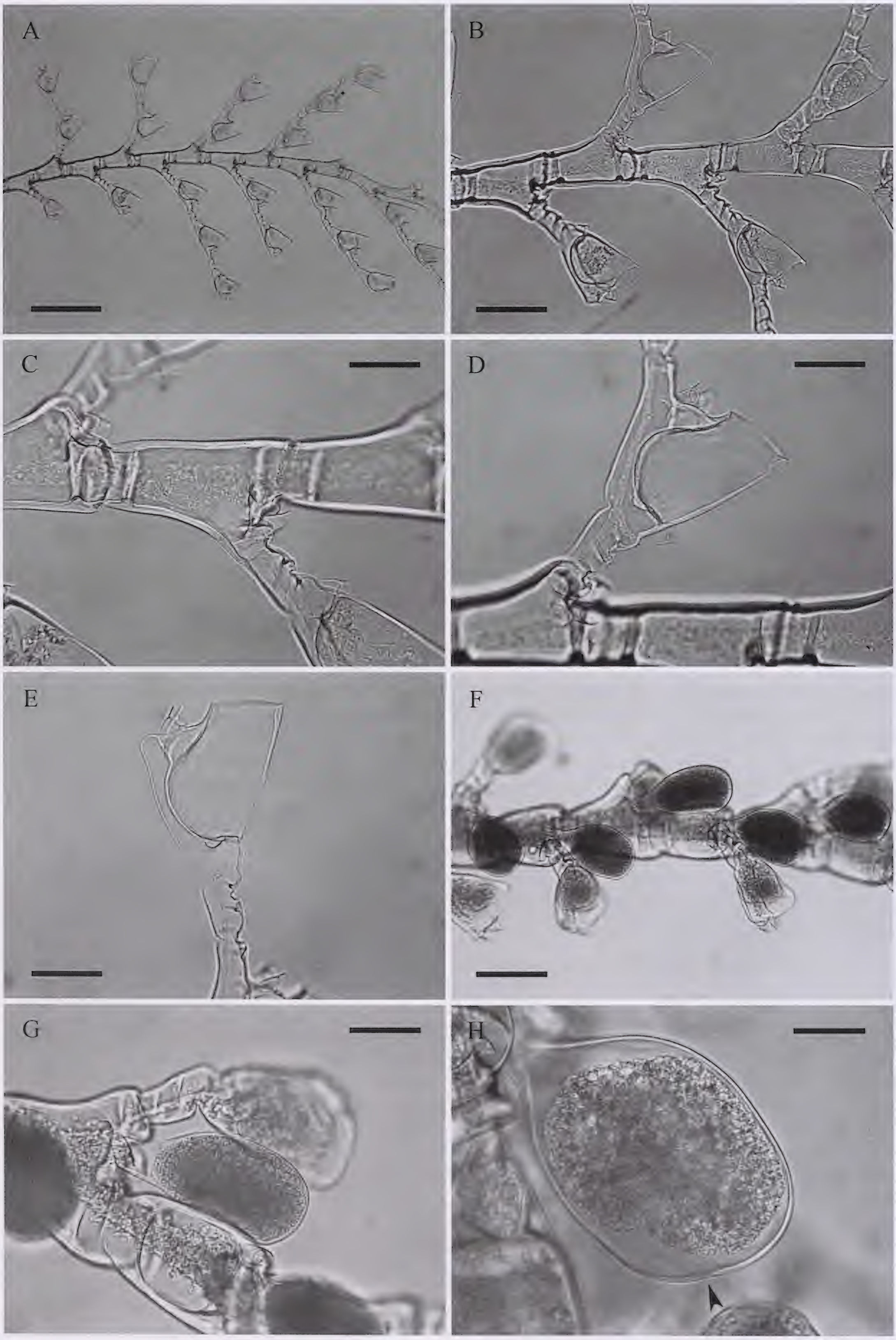
Figs 1-2; Tables 1-2

Holotype: MHNG-INVE-137167; INDONESIA, Bali, Pererenan beach; -8.650831°, 115.119820°; 13 Jan. 2020; fertile colony on red alga.

Paratypes: MHNG-INVE-137168; INDONESIA, Bali, Pererenan beach; -8.650831°, 115.119820°; 13 Jan. 2020; fertile colony on red alga. – MHNG-INVE-137169; INDONESIA, Bali, Pererenan beach; -8.650831°, 115.119820°; 13 Jan. 2020; fertile colonies on 3 fragments of red algae.

Diagnosis: Small-sized, epiphytic *Plumularia* arising from stolon with perisarcal spurs, giving rise to monosiphonic stems divided homomerously by transverse nodes into rather short, collinear internodes, each with a subterminal cladial apophysis provided with an inconspicuous adaxial mamelon and a pair of axillar nematothecae; cladia heteromerously segmented by alternating straight and oblique nodes into short, ahydrothecate internodes occasionally provided with a nematotheca, and up to three, comparatively longer hydrothecate internodes accommodating a centrally-placed hydrotheca and its three associated nematothecae; hydrotheca deep, saccate, partly adnate, distal portion distinctly constricted through the hypertrophy of the free adaxial wall that adopts a triangular shape, considerably reducing the thecal lumen; abaxial wall slightly convex; gonothecae in two closely-set, parallel rows along the stem, borne on the cladial apophyses, minute, ovoid, thick-walled.

Manuscript accepted 22.07.2020
DOI: 10.35929/RSZ.0026


A
B
C
D
E
F
G
H

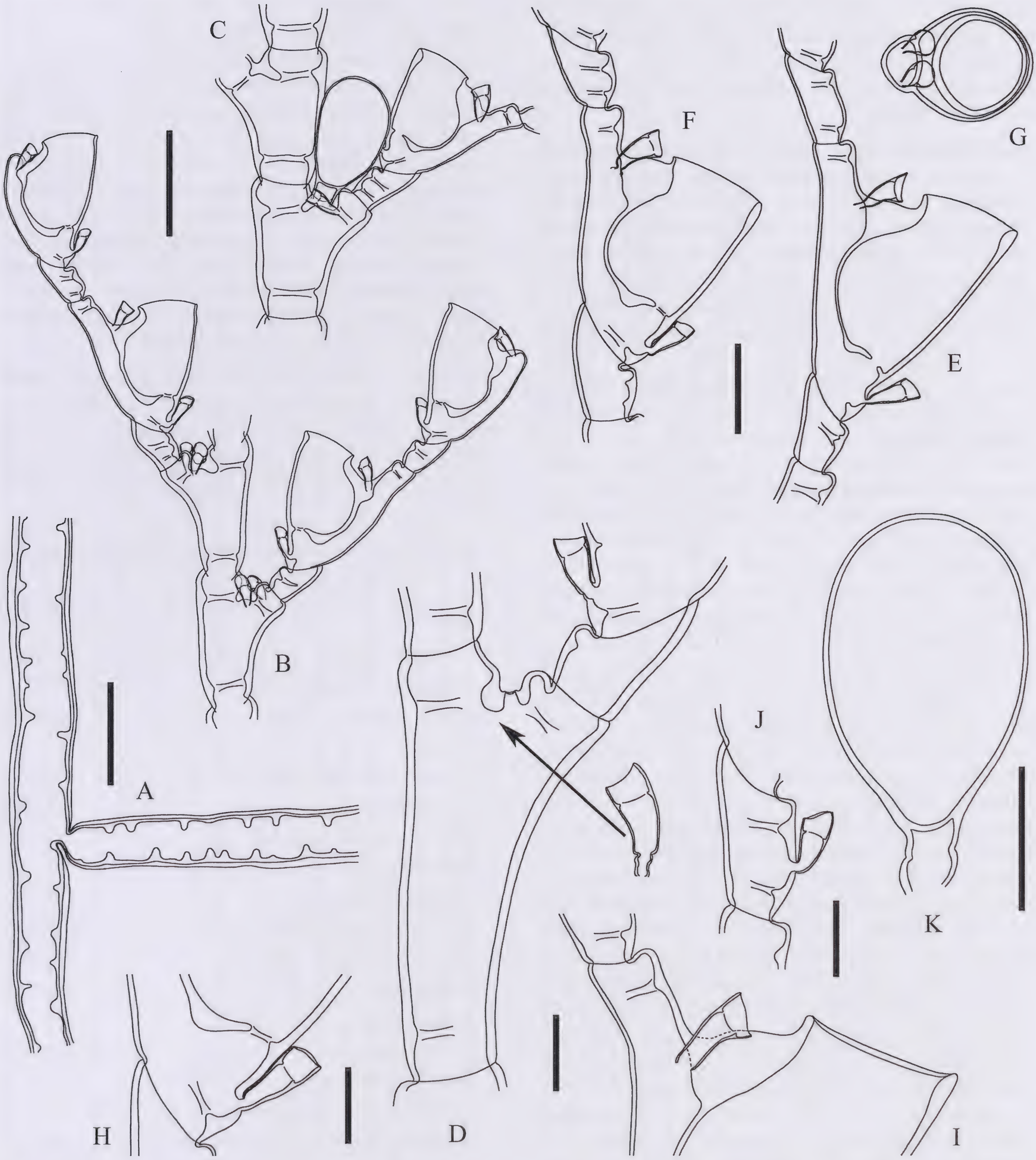


Fig. 2. *Plumularia roxanae* sp. nov. (A) Portion of ramified stolon, showing internal spurs. (B) Two stem internodes and proximal parts of their corresponding cladia. (C) Portion of stem with gonotheca. (D) Detail of stem internode. (E, F) Two hydrothecae seen laterally, note differences in the adaxial perisarc thickening. (G) Hydrotheca seen from above, note the position of lateral nematothecae. (H) Base of hydrotheca with mesial nematotheca. (I) Distal part of hydrotheca with lateral nematotheca. (J) Cladial ahydrothecate internode. (K) Gonotheca. Scale bars: 50 μm (D, H-K), 100 μm (E-G), 200 μm (B, C), 300 μm (A).

Fig. 1. *Plumularia roxanae* sp. nov. (A) Portion of cormoid. (B) Detail of a portion of stem with proximal parts of four successive cladia. (C) Detail of a stem internode, showing centrally an apophysis and the proximal part of the corresponding cladium. (D) Proximal most hydrotheca. (E) Distalmost hydrotheca, note the absence of the distal part of its corresponding internode. (F) Portion of fertile stem with rows of gonothecae. (G) Gonotheca. (H) More detailed view of a gonotheca, showing apical aperture (arrowhead). Scale bars: 50 μm (H), 100 μm (C-E, G), 200 μm (B, F), 500 μm (A).

◀

Etymology: It is my great pleasure to dedicate this new species to the memory of my late mother, Roxana S. Galea (née Florescu, 5 Oct. 1946 – 18 Jan. 1994), a Romanian biologist, who passed on to me her interest for natural sciences.

Description: Colonies epiphytic on algae, composed of numerous erect cormoids arising from creeping, branching, flattened stolonal tubes firmly attached to substrate; lumen with two lateral rows of perisarcal spurs; a wide flange of thinner perisarc flanking outer lateral sides. Stems short, up to 5 mm high, with thick and firm perisarc, gradually thinning out distally; monosiphonic, divided by means of transverse nodes into a regular sequence of collinear, rather short internodes, length slightly increasing gradually towards tips of cormoids; each internode with two internal perisarc ridges (one above proximal node, the second below the distal node) and a subterminal cladial apophysis; apophyses alternate along the stem, the two rows either in one plane in some specimens or variably shifted on to the anterior side of the colony in others; apophyses well-developed, each with a subterminal, internal perisarc ridge, an inconspicuous mamelon (reduced to a mere pore) with small, circular aperture on adcauline side, and a pair of axillar nematothecae, one to each lateral side; distal node straight. Cladia given off at an angle of about 45° with the long axis of the stem; up to 1 mm long, divided heteromerously by an alternation of deeply-incised, straight and oblique nodes delimiting a- and hydrothecate internodes; first cladial internode ahydrothecate; all ahydrothecate internodes short, with proximal node straight and distal node oblique, with two internal perisarc ridges (one proximal, one distal) and, occasionally, with a nematotheca in middle of upper side; hydrothecate internodes, up to 3 per cladium, comparatively longer than their ahydrothecate counterparts, slightly sigmoid in overall shape, with proximal node oblique and distal node straight, a centrally-placed hydrotheca (together with its 3 associated nematothecae), occupying more than half the length of the internode, and two internal perisarc ridges near both ends. Hydrotheca deep, saccate, adnate for about 2/3 to its corresponding internode; abaxial wall thick, slightly convex proximally; free adaxial wall exceedingly hypertrophied, adopting a triangular shape, free angle upturned; adnate adaxial wall moderately thick, forming an L-shaped perisarc thickening at junction with the hydrothecal base, the latter pierced by circular foramen for the passage of the hydranth; hydrothecal aperture facing nearly upwards, rim entire, circular in apical view; mesial nematotheca well below the hydrothecal base, mounted on small prominence of the internode; lateral nematothecae borne on indistinct apophyses and hidden by the free portion of the adaxial wall when the hydrotheca is seen frontally, and typically inclined over this side of the thecal wall; hydranths able to completely retract into their corresponding hydrothecae, with ca. 12 filiform tentacles in a whorl around a dome-shaped hypostome. All nematothecae of the colony movable, elongate-conical in shape and bithalamic; lower chamber comparatively taller than upper one, the latter with the wall slightly lowered on adaxial side. Gonothecae in two parallel, closely-set rows along the stem, arising singly from the anterior side of each cladial apophysis; likely male in the present material, with a homogenous, granular content; elongate-globular, thick-walled, with smooth outer surface, apically with a small funnel-shaped aperture in some specimens, delimited basally by transverse, thick diaphragm from a short, tubular pedicel.

Remarks: Upon a comparison with all shallow-water, small-sized (generally not surpassing 1 cm high), short-cladiate, nominal species of *Plumularia* Lamarck, 1816 from the tropical Indian and western Pacific oceans (Table 1), it appears that the material at hand is

Table 1. Measurements of *Plumularia roxanae* sp. nov., in µm.

Stem	
- internodes, length	220-285
- internodes, diameter at node	45-95
- cladial apophyses, length	40-45
Cladia	
- ahydrothecate internodes, length	65-95
- hydrothecate internodes, length	255-300
- diameter at transverse node	30-40
Hydrotheca	
- abaxial wall, length	180-195
- free adaxial wall, length	75-85
- adnate adaxial wall, length	110-120
- diameter at rim	100-115
Nematothecae	
- axillar, length	60-65
- axillar, diameter at rim	ca. 25
- of ahydrothecate internodes, length	ca. 40
- of ahydrothecate internodes, diameter at rim	ca. 25
- mesial, length	ca. 55
- mesial, diameter at rim	ca. 25
- lateral, length	55-60
- lateral, diameter at rim	ca. 35
Gonotheca	
- length	195-220
- maximum width	135-140
- pedicel, length	45-50
- pedicel, width	40-45

Table 2. Nominal species of *Plumularia* Lamarck, 1816 from the tropical Indo-west Pacific, and their distinctive features to *P. roxanae* sp. nov.

Nominal species	**Distinctive features to *P. roxanae* sp. nov. Remarks. Habitat**	**Distribution and references**
P. amphibola (Watson, 2011)	Nominal species indistinguishable morphologically from *P. crateriformis* Mulder & Trebilcock, 1911, from which it was separated only on the account of the presence of single hydrothecate internodes on cladia. Epiphytic	Australia (Watson, 2011)
P. angusta Stechow, 1923	Nominal species created by Stechow (1923: 226) for 3 varieties (a, b, d) of *P. setaceoides* Bale, 1882 dealt with by Mulder & Trebilcock (1911: pl. 3 figs 3-3b, pl. 3 fig. 6, pl. 2 fig. 9, respectively). Subsequently reported upon by Watson (1975: figs 30-31). No comprehensive description available, but morphology of both hydro- and gonothecae similar to that of the better-known *P. wilsoni* Bale, 1926 (see below), with which it could be conspecific, in that case having priority. Presumably epiphytic	Australia, Tasmania (Mulder & Trebilcock, 1911; Watson, 1975)
P. australis Kirchenpauer, 1876	Stem internodes moderately-long, geniculate; cladial apophyses with a mamelon and an axillar nematotheca; cladia composed of a proximal, short, athecate internode, followed by a hydrothecate internode; hydrotheca seated in a concavity of internode, slightly compressed laterally, abaxial wall distinctly cambered, adaxial wall projecting a strong, oblique intrathecal septum, rim weakly to noticeably sinuous; dioecious, 1-3 gonothecae on lower stem internodes, large, flask-shaped, body narrowing distally to an upwardly bent, cylindrical neck, with a wide, circular, thickened aperture with broadly everted rim. Epiphytic	Australia (Watson, 1990, 2011)
P. caliculata Bale, 1888	Stem internodes moderately-long, slightly geniculate, with internal septa at both ends, and 1 nematotheca; cladial apophyses with low mamelon and 1 axillar nematotheca; cladia heteromerous, internodes with septa at both ends, up to 5 hydrothecate internodes; hydrothecae cup-shaped, shallow, fully adnate, abaxial wall thickened and swollen basally; monoecious, gonothecae forming a continuous row on front of stem, attached to successive cladial apophyses just under mamelon, female globular with external marsupium, male elongated. Epiphytic	Australia, New Zealand, Japan (Vervoort & Watson, 2003)
P. compressa Bale, 1882	The hydro- and gonothecae of this nominal species appear indistinguishable from those of *P. australis* Kirchenpauer, 1876 (see above); compare Bale (1882: p. 15, figs 5-5a), Bale (1884: pl. 12 figs 9-10, pl. 19 figs 39-40) and Bale (1888: pl. 19 fig. 14) with Bale (1884: pl. 12 figs 7-8, pl. 19 figs 43-44) and Watson (1990: figs 177-182), respectively. If the synonymy is accepted, Kirchenpauer' species has priority. Epiphytic	Australia (Watson, 2005)
P. corrugatissima Mulder & Trebilcock, 1914	Nominal species inaccurately described. Stem internodes with 1 nematotheca; cladial apophyses with 2 nematothecae; cladia heteromerous, hydrothecate internodes distinctly swollen; hydrothecae small, cup-shaped, shallow, about as deep as wide, fully adnate, rim everted frontally, aperture somewhat oblique; gonothecae unknown. Presumably epiphytic	Australia (Mulder & Trebilcock, 1914; Bale, 1919)
P. crateriformis Mulder & Trebilcock, 1911	Stolon with nematothecae. Stems divided by strongly oblique nodes; internodes short, robust, with several thick complete internal septal ridges, and 1 nematotheca; cladial apophyses with 1 axillar nematotheca; ahydrothecate internodes with 1 nematotheca, with the exception of the proximal most; hydrothecae perched on bulges of upper side of hydrothecate internodes, alternating with 3 strong septal ridges; symmetrical, cup-shaped, walls expanding to margin, base rounded, aperture outrolled; 1-3 gonothecae in lower stem region, often of both sexes, urn-shaped, distally a dome-shaped cap, gonophore with row of refringent corpuscles. Epiphytic	Australia (Mulder & Trebilcock, 1911; Watson, 1990, 2005)
P. crateroides Mulder & Trebilcock, 1911	Nominal species inaccurately described. Stolon with nematothecae; stem internodes "with about three transverse wrinkles" and 1 nematotheca; cladial apophyses with 1 nematotheca; cladia heteromerous; hydrothecae cup-shaped, rather shallow, expanding upwards, partly adnate to the corresponding internode; gonothecae given off singly from base of stem, "somewhat flattened beneath, convex on top, obliquely truncated, aperture very large, margin everted". Presumably epiphytic	Australia (Mulder & Trebilcock, 1911)

Nominal species	Distinctive features to *P. roxanae* sp. nov. Remarks. Habitat	Distribution and references
P. epibracteolosa Watson, 1973	Stem divided by strongly oblique nodes; internodes with 3-4 internal ridges of perisarc, and 1 nematotheca; cladial apophyses with an axillar nematotheca besides the adaxial pore; cladial hydrothecate internodes with 4-5 internal ridges of perisarc; hydrothecae wide, shallow, cup-shaped; abaxial wall distinctly thickened; adaxial wall adnate to hydrocladium only near base, the remainder joined to the internode by a wedge of perisarc; margin sinuated, with a thickened outwardly rolled rim, the line of the margin curved down posteriorly to meet the internode; aperture truncated adaxially by a delicate transverse sheet of perisarc; a couple of large, piriform gonothecae arising from old, basal hydrocladial apophyses. Epiphytic	Australia, New Zealand (Watson, 1973; Vervoort & Watson, 2003)
P. excavata Mulder & Trebilcock, 1911	Nominal species inaccurately described. Stem "annulated", without nematothecae; cladia bearing single, concave hydrothecate internodes; hydrothecae cup-shaped, partly adnate, abaxial wall distinctly sigmoid (strongly concave proximally, convex distally); gonothecae unknown. Presumably epiphytic	Australia (Mulder & Trebilcock, 1911)
P. filicaulis Kirchenpauer, 1876	Colonies with sessile cladia and/or erect stems; stem divided by oblique nodes; internodes moderately-long, with 1 nematotheca; cladial apophyses with mamelon and 1 axillar nematotheca; cladia heteromerous, with up to 6 hydrothecate internodes; hydrothecae cup-shaped, basally adnate, abaxial wall slightly rounded, adaxial wall giving rise to an intrathecal septum, margin forming an angle of 45° with the internode, produced to form a peak on both the ad- and abaxial sides; gonothecae borne on hydrorhiza, firmly applied to substratum, flattened, thick-walled, irregularly ovate in outline, aperture small, circular on upper surface of distal end, a number of minute pores on upper surface. Epiphytic	South Africa, Australia, Japan, Madagascar (Millard, 1975; Watson, 2005)
P. flexuosa Bale, 1894	Stem occasionally branched; internodes moderately-long, geniculate, with 1 nematotheca; cladial apophyses with 1-2 axillar nematothecae, as well as an additional nematotheca on the apophysis itself; hydrothecae deeply campanulate, expanding to aperture, abaxial wall weakly concave, adaxial wall almost straight, a small portion free from the internode; dioecious, gonothecae on lower stem internodes, elongate-ovoid, twice as long as wide, distal end tapering, truncate above and there provided with a rather small, somewhat oblique aperture, without submarginal teeth. Epiphytic and epizoic	Australia, New Zealand, Japan (Bale, 1894; Watson, 1973, 2000, 2005)
P. floridana Nutting, 1900	Stem internodes relatively long, slender, slightly geniculate, each with an internal perisarc ridge at each end, and 1 nematotheca; cladial apophyses with mamelon and 2 axillar nematothecae; cladia heteromerous, ahydrothecate internodes moderately-long and with 1 nematotheca, hydrothecate internodes with a centrally-placed hydrotheca; the latter fairly deep, cylindrical, half adnate; gonothecae small, globular, thin-walled, borne on cladial apophyses. Epiphytic	Circumglobal in warm waters (Ansín Agís *et al*., 2001)
P. fragilia Watson, 2012	Stem internodes long, slender, with 2 nematothecae on opposite sides; cladial apophyses with a bun-shaped mamelon and 2 axillar nematothecae; cladia heteromerously segmented into long a- and hydrothecate internodes, the former with 1 nematotheca; hydrothecae seated about halfway along the internodes, small, deep bowl-shaped, abaxial wall deeply concave to straight, adaxial wall weakly concave and fully adnate to internode, margin oblique to internode axis, circular, rim everted; gonothecae unknown. Epizoic	Australia (Watson, 2012)
P. goldsteini Bale, 1882	Nominal species inadequately described, though easily recognizable through the peculiar shape of its hydrothecae. Cladia heteromerous, with up to 4 hydrothecate internodes; hydrotheca slipper-shaped, long axis strongly sigmoid, base distinctly swollen, aperture facing away from the internode; gonothecae unknown. Epiphytic	Australia (Bale, 1882, 1884 ; Watson, 1973)

Nominal species	Distinctive features to *P. roxanae* sp. nov. Remarks. Habitat	Distribution and references
P. hyalina Bale, 1882	Stem internodes of varied length, with or without internal septa, with 0-1 nematotheca; cladial apophysis with conical mamelon and 1 axillar nematotheca; hydrotheca deep bowl-shaped, abaxial wall slightly convex, adaxial wall concave and fully adnate to internode, margin a broad sinuous curve down to internode; one to several gonothecae in a row around lower stem, large, piriform, walls smooth to obscurely undulated, when mature flattened at top, and opening by a large, smooth-edged, circular aperture, gonophore with belt of refringent corpuscles. Epiphytic and epizoic	Australia (Mulder & Trebilcock, 1911; Trebilcock, 1928; Watson, 2011)
P. lucerna Mulder & Trebilcock, 1911	Very likely a stemless variety of *P. filicaulis* Kirchenpauer, 1876 (see above); compare Mulder & Trebilcock (1911: pl. 3 fig. 4) with Bale (1884: pl. 11 figs 6-7). Presumably epiphytic	Australia (Mulder & Trebilcock, 1911)
P. meretricia Watson, 1973	Stem internodes long, slender, occasionally with 1-2 nematothecae, often absent; cladial apophyses with prominent mamelon (with 1-2 apertures) adaxially and 1 axillar nematotheca, the latter often absent; hydrothecae campanulate, abaxial wall straight for most of its length, expanding below aperture; margin everted, slightly sinuated, curving down adaxially; gonothecae unknown. Epizoic	Australia (Watson, 1973, 2005)
P. mooreana Schuchert, 2013	Stem internodes relatively short, sturdy, each with 1 nematotheca; cladial apophyses with 1 axillar nematotheca; cladia heteromerous, with up to 4 relatively short hydrothecate internodes, each with a centrally-placed hydrotheca; the latter bowl-shaped, shallow, inclined downward at 45° with the internode; 1-2 gonothecae near stem bases, borne on laterally-set pedicels, urn-shaped, perisarc undulated, outer surface with scattered nematothecae. Inert substrates	French Polynesia, Fiji (Schuchert, 2013b)
P. obesa Blackburn, 1938	Stem internodes short, sturdy; cladial apophyses with mamelon and 1-2 nematothecae; cladia with single, short, concave hydrothecate internode, accommodating distally a hydrotheca; the latter laterally compressed, abaxial wall sigmoid, adaxial wall fully fused, concave, giving rise to a forwardly and upwardly-directed intrathecal ridge, margin sinuous, somewhat everted abaxially, distinctly lowered adaxially; gonothecae unknown. Epiphytic	Australia (Blackburn, 1938; Watson, 1990)
P. obliqua Johnston, 1847	Stem internodes moderately long, geniculate, with 1 nematotheca; cladial apophyses with conical mamelon and 1 axillar nematotheca; hydrothecate cladial internode with 2 internal septa behind the hydrotheca, the latter distal on internode, scoop-shaped, fully adnate, abaxial wall smoothly convex, thickened or not, margin cut obliquely back to internode, rim slightly everted, a perisarc thickening behind; gonothecae on lower stem internodes, large, urn-shaped, perisarc fairly thick, distally truncate, aperture closed by sheet of tissue; gonophore a medusoid. Epiphytic	Circumglobal in temperate to tropical waters (Watson, 2011)
P. pulchella Bale, 1882	Stem internodes robust, moderately long, with several transverse internal septa and 1 nematotheca; cladial apophyses with 2 axillar nematothecae; hydrothecate internodes short, concave, hydrotheca distally-placed, fully adnate, cup-shaped, slightly flaring, abaxial wall weakly concave, variably thickened; dioecious, gonothecae on lower stem internodes, at base of a cladial apophysis, large, globular, thick-walled, smooth to faintly rugose, aperture distal, set obliquely, aperture narrow, circular, with a row of large, internal submarginal cusps. Epiphytic	Australia (Watson, 1973, 2011)
P. rotunda Mulder & Trebilcock, 1911	Stem internodes moderately long, slightly geniculate, with 1 nematotheca; cladial apophyses with 1 axillar nematotheca; cladia heteromerously segmented, ahydrothecate internodes short and with 1 nematotheca, hydrothecate internodes up to 2, comparatively longer, each with a hydrotheca distally; hydrothecae elliptic, abaxial wall strongly arched, becoming thicker towards aperture where it is incurved, appearing as a submarginal septum, aperture small, set obliquely forwards, subrectangular, rim weakly lobate; gonothecae unknown. Epiphytic	Australia (Bale, 1919; Watson, 2015)
P. spinulosa Bale, 1882	Stem internodes moderately long and slender, with 1 nematotheca; cladial apophyses with mamelon and 1 axillar nematotheca; cladia with single, concave hydrothecate internode, ending in a distal spine of variable length, projecting beyond hydrotheca; the latter bonnet-shaped, fully adnate, laterally compressed, abaxial wall convex, a strong adaxial intrathecal septum projecting halfway across lumen, aperture sinuated adaxially; one to several gonothecae on lower cladial apophyses, large, elongated-conical, sometimes curved asymmetrically, with wide terminal aperture set perpendicularly to long axis. Epiphytic and epizoic	Australia, New Zealand, South Africa, Japan (Millard, 1975; Watson, 2011)

Nominal species	Distinctive features to *P. roxanae* sp. nov. Remarks. Habitat	Distribution and references
P. strictocarpa Pictet, 1893	Stolon with nematothecae; cauline internodes long, slender, slightly geniculate, with 1-2 nematothecae; cladial apophyses with mamelon and 1 axillar nematotheca; cladia heteromerous, ahydrothecate internodes relatively long, with internal septa at both ends and 1 nematotheca; hydrothecate internodes comparatively longer, with up to 3 internal septa; hydrothecae conical, fully adnate, margin rounded, tilted abaxially; gonothecae borne below lower cladial apophyses, large, partly or fully seated on substrate, barrel-shaped in frontal view, flattened dorso-ventrally, distinctly transversely ridged, aperture distal, circular. Epiphytic, epizoic, also growing on inert substrates	Circumglobal in warm waters (Ryland & Gibbons, 1991; Hirohito, 1974)
P. togata Watson, 1973	Cauline internodes moderately long and slender, with 1 nematotheca; cladial apophyses with conical mamelon and 1 axillar nematotheca; hydrotheca slipper-shaped, longitudinal axis S-shaped, abaxial wall considerably produced frontally, aperture narrowed and tilted adaxially; gonotheca borne beside apophysis of first stem internode, large, urn-shaped, distally truncate, walls smooth to weakly undulated, aperture closed by sheet of tissue. Epiphytic	Australia (Watson, 1973, 2011)
P. tubacarpa Watson, 2000	Cauline internodes long, each with 1-4 cladial apophyses (usually 2) and a variable number of nematothecae, 1 in axil of apophysis, 1 beside apophysis, 1 halfway between hydrocladia and sometimes 1 at side of internode just above node; cladia divided homomerously into quite long hydrothecate internodes; hydrothecae deep cup-shaped, adaxial wall entirely adnate, abaxial wall straight to faintly sinuous, concave just behind margin; gonothecae exceedingly long, tubular, rounded apically. Epizoic	Australia (Watson, 2000)
P. warreni Stechow, 1919	Stem internodes moderately long, with 1 frontal nematotheca; cladial apophyses with 1 axillar nematotheca; cladia heteromerous, ahydrothecate internodes short, with internal septa near ends, and 1 nematotheca, hydrothecate internode comparatively longer, with internal septa near ends and a centrally-placed hydrotheca; the latter inverted conical, completely adnate, margin slightly oblique; monoecious, gonothecae on cladial apophyses, elongate-ovoid, outline irregular, slightly flattened dorso-ventrally. Epiphytic	From South Africa to Australia (Millard, 1975)
P. wilsoni Bale, 1926	Stolon with internal pegs and nematothecae; stem internodes relatively short, with internal ridges near their ends, and 1 nematotheca on side opposite to cladial apophysis; the latter with 2 axillar nematothecae; cladia heteromerous, hydrothecate internodes relatively long, with a centrally-placed hydrotheca; abaxial wall sigmoid, thickened, adaxial wall free for 1/3 from corresponding internode, concave, aperture tilted abaxially; gonothecae borne on lower stem internodes, large, piriform, transversely ridged, distal end truncate. Presumably epiphytic, also epizoic	Australia, Tasmania, New Zealand (Ralph, 1961; Watson, 2015)

distinctive, mainly through the shape of its hydrothecae. Similar gonothecae are only found in *P. floridana* Nutting, 1900, a species of circumtropical occurrence, described under various names (Calder, 1997: 15).

The epiphytic hydroid erroneously assigned (Watson, 2011: 78) to *Monotheca hyalina* (Bale, 1882) by Vervoort & Watson (2003) resembles the present species, notably in the structure of the colony and the shape of hydrotheca, but shows several differences: 1) its stolon is devoid of perisarc spurs; 2) there is only one axillar nematotheca associated to the cladial apophyses of the stem; 3) the hydrothecae are devoid of the characteristic thickening of the free adaxial wall; 4) its (female) gonothecae are much bigger, ca. 1 mm high, as deduced from their fig. 90I, and they are piriform, with an apical, broad, circular aperture closed by an operculum. For these reasons, their record is not included in the synonymy of the present species, pending the discovery of colonies belonging to the opposite (female) sex.

Distribution: Known only from Bali, Indonesia, but presumably spread throughout the archipelago.

ACKNOWLEDGEMENTS

This study was made possible through a grant (App #40579/2019) from the PADI Foundation, Beverly Hills, CA, USA. I am grateful to Prof. Fran Ramil (University of Vigo, Spain) and Dr Henry H.C. Choong (Royal British Columbia Museum, Canada) for their thorough review of the manuscript.

REFERENCES

Ansín Agís J., Ramil F., Vervoort, W. 2001. Atlantic Leptolida (Hydrozoa, Cnidaria) of the families Aglaopheniidae, Halopteridídae, Kirchenpaueriidae and Plumulariidae collected during the CANCAP and Mauritania-II expeditions of the National Museum of Natural History, Leiden, the Netherlands. *Zoologische Verhandelingen, Leiden* 333: 1-268.

Bale W.M. 1882. On the Hydroida of south-eastern Australia, with descriptions of supposed new species, and notes on the genus *Aglaophenia*. *Journal of the Microscopical Society of Victoria* 2(1): 15-48.

Bale W.M. 1884. Catalogue of the Australian hydroid zoophytes. *Australian Museum, Sydney*, 198 pp.

Bale W.M. 1888. On some new and rare Hydroida in the Australian Museum collection. *Proceedings of the Linnean Society of New South Wales* 2(3)2: 745-799.

Bale W.M. 1894. Further notes on Australian hydroids, with descriptions of some new species. *Proceedings of the Royal Society of Victoria* 6: 93-117.

Bale W.M. 1919. Further notes on Australian hydroids. IV. *Proceedings of the Royal Society of Victoria* 31(2): 327-362.

Bale W.M. 1926. Further notes on Australian hydroids. V. *Proceedings of the Royal Society of Victoria* 38: 13-23.

Blackburn M. 1938. Hydrozoa. *In*: The Sir Joseph Banks Islands. Reports of the expedition of the McCoy Society for Field Investigation and Research, 3. *Proceedings of the Royal Society of Victoria* 50(2): 312-328.

Bouillon J., Gravili C., Pagès F., Gili J.M., Boero F. 2006. An introduction to Hydrozoa. *Mémoires du Muséum national d'Histoire naturelle, Paris* 194: 1-591.

Calder D.R. 1997. Shallow-water hydroids of Bermuda: superfamily Plumularioidea. *Royal Ontario Museum Life Sciences Contributions* 161: 1-84.

Fraser C.M. 1938a. Hydroids of the 1934 Allan Hancock Pacific Expedition. *Allan Hancock Pacific Expeditions* 4(1): 1-105.

Fraser C.M. 1938b. Hydroids of the 1936 and 1937 Allan Hancock Pacific Expeditions. *Allan Hancock Pacific Expeditions* 4(2): 107-127.

Fraser C.M. 1938c. Hydroids of the 1932, 1933, 1935, and 1938 Allan Hancock Pacific Expeditions. *Allan Hancock Pacific Expeditions* 4(3): 129-153.

Fraser C.M. 1948. Hydroids of the Allan Hancock Pacific Expeditions since March, 1938. *Allan Hancock Pacific Expeditions* 4(5): 179-343.

Galea H.R. 2007. Hydroids and hydromedusae (Cnidaria: Hydrozoa) from the fjords region of southern Chile. *Zootaxa* 1597: 1-116.

Galea H.R. 2008. On a collection of shallow-water hydroids (Cnidaria: Hydrozoa) from Guadeloupe and Les Saintes, French Lesser Antilles. *Zootaxa* 1878: 1-54.

Hirohito, Emperor of Japan. 1974. Some hydrozoans of the Bonin Islands. *Publications of the Biological Laboratory, Imperial Household, Tokyo* 11: 1-55.

Johnston G. 1847. A history of the British zoophytes. *John van Voorst, London*, XVI + 488 pp.

Kirchenpauer G.H. 1876. Ueber die Hydroidenfamilie Plumularidae, einzelne Gruppen derselben und ihre Fruchtbehälter. II. *Plumularia* und *Nemertesia*. *Abhandlungen aus dem Gebiete der Naturwissenschaften, Hamburg* 6(2): 1-59.

Lamarck J.B. 1816. Histoire naturelle des animaux sans vertèbres. *Verdière, Paris*, 568 pp.

Millard N.A.H. 1975. Monograph on the Hydroida of southern Africa. *Annals of the South African Museum* 68: 1-513.

Mulder J.F., Trebilcock R.E. 1911. Notes on Victorian Hydroida, with description of new species. (Continued). *Geelong Naturalist* 4(4): 115-124.

Mulder J.F., Trebilcock R.E. 1914. Victorian Hydroida. With description of new species. Part IV. *Geelong Naturalist* 6(2): 38-47.

Mulder J.F., Trebilcock R.E. 1915. Victorian Hydroida. With description of new species. Part V. *Geelong Naturalist* 6(3): 51-59.

Nutting C.C. 1900. American hydroids. Part I. The Plumularidae. *Special Bulletin of the United States National Museum* 4(1): 1-285.

Pictet C. 1893. Etude sur les Hydraires de la Baie d'Amboine. *Revue suisse de Zoologie* 1: 1-64.

Ralph P.M. 1961. New Zealand thecate hydroids. Part IV. Family Plumulariidae. *Transactions of the Royal Society of New Zealand* 1(3): 19-74.

Ryland J.S., Gibbons M.J. 1991. Intertidal and shallow water hydroids from Fiji. II. Plumulariidae and Aglaopheniidae. *Memoirs of the Queensland Museum* 30(3): 525-560.

Schuchert P. 2013a. The status of *Plumularia lagenifera* Allman, 1885 (Cnidaria, Hydrozoa) and related species. *Zootaxa* 3613(2): 101-124.

Schuchert P. 2013b. *Plumularia mooreana*, a new marine hydroid from French Polynesia (Hydrozoa, Cnidaria). *Revue suisse de Zoologie* 120(3): 405-413.

Stechow E. 1919. Zur Kenntnis des Hydroidenfauna des Mittelmeeres, Amerikas und anderer Gebiete, nebst Angaben über einige Kirchenpauer'sche Typen von Plumulariden. *Zoologische Jahrbücher* 42(1): 1-172.

Stechow E. 1923. Zur Kenntnis des Hydroidenfauna des Mittelmeeres, Amerikas und anderer Gebiete. II. Teil. *Zoologische Jahrbücher* 47(1): 29-270.

Trebilcock R.E. 1928. Notes on New Zealand Hydroida. *Proceedings of the Royal Society of Victoria.* New series. 41: 1-33, plates 1-7.

Vervoort W., Watson J.E. 2003. The marine fauna of New Zealand: Leptothecata (Cnidaria: Hydrozoa) (thecate hydroids). *NIWA Biodiversity Memoir* 119: 1-538.

Watson J.E. 1973. Pearson Island Expedition 1969. – 9. Hydroids. *Transactions of the Royal Society of South Australia* 97(3): 153-200.

Watson J.E. 1975. Hydroids of Bruny Island, southern Tasmania. *Transactions of the Royal Society of South Australia* 99(4): 157-176.

Watson J.E. 1990. Studies on Australian hydroids. The genus *Eudendrium* and the fauna of the seagrass *Amphibolis*. *Deakin University*, *Melbourne*, 288 pp.

Watson J.E. 2000. Hydroids (Hydrozoa: Leptothecata) from the Beagle Gulf and Darwin Harbour, northern Australia. *The Beagle, Records of the Museum and Art Galleries of the Northern Territory* 16: 1-82.

Watson J.E. 2005. Hydroids of the Archipelago of the Recherche and Esperance, Western Australia: annotated list, redescription of species and description of new species [pp. 495-611]. *In:* Wells F.E., Walker D.I., Kendrick G. (eds), The Marine Flora and fauna of Esperance, Western Australia. *Western Australian Museum*, *Perth*, 727 pp.

Watson J.E. 2011. Review of the genus *Monotheca* (Hydrozoa: Leptolida) from Australia with description of a new species and a note on *Monothecella* Stechow, 1923. *Memoirs of Museum Victoria* 68: 71-91.

Watson J.E. 2012. Some hydroids (Hydrozoa: Hydroidolina) from Dampier, western Australia: annotated list with description of two new species. *Memoirs of Museum Victoria* 69: 355-363.

Watson J.E. 2015. A new species of *Halopteris* (Hydrozoa: Leptothecata) and redescription of *Plumularia rotunda* from Victoria, Australia. *Memoirs of the Museum Victoria* 73: 41-46.

Revue suisse de Zoologie (September 2020) 127(2): 377-380 ISSN 0035-418

Description of *Cerochusa gesinae* sp. nov. from Thailand (Coleoptera: Staphylinidae: Pselaphinae)

Zi-Wei Yin[1] & Andreas Kleeberg[2]

[1] *Laboratory of Systematic Entomology, College of Life Sciences, Shanghai Normal University, 100 Guilin Road, Xuhui District, Shanghai 200234, China. E-mail: pselaphinae@gmail.com*

[2] *Zum Alten Windmühlenberg 26, D-12524 Berlin, Germany. E-mail: a.g.kleeberg@t-online.de*

Abstract: A second species of the genus *Cerochusa* Yin & Nomura, 2012, *C. gesinae* Yin & Kleeberg, sp. nov., is described and illustrated from Chiang Mai, Thailand. The new species can be easily distinguished from *C. cilioceps* Yin & Nomura, 2012 from China and Thailand by the less strongly modified male head, distinct discal striae of the elytra, dense pubescence along the posterior margin of the elytra, and different shape of the aedeagus.

Keywords: *Cerochusa*, new species, taxonomy, Thailand.

INTRODUCTION

The monotypic ant-loving beetle genus *Cerochusa* Yin & Nomura, 2012 (Batrisitae: Batrisini) was erected to hold a robust-looking species from Hainan Island, southern China (Yin *et al.,* 2012). Later collection records of the type species, *C. cilioceps* Yin & Nomura, 2012, illustrated a wider distributional range of this species in Southeast Asia (Yin & Li, 2014). In November, 2019 the second author conducted a field work in northern Thailand. Among the pselaphines collected at Doi Suthep National Park, an additional species of *Cerochusa* was recognized, which is described in the present paper. The diagnosis of the genus is updated in light of the discovery of a second species.

MATERIAL AND METHODS

The type material of the new species described in this paper is deposited in the Museum für Naturkunde Berlin, Germany (MNB). The text of the specimen label is quoted verbatim in quotation marks, supplemental information is included in parentheses.

Genital parts were dissected and preserved in Euparal on a plastic slide that was placed on the same pin with the specimen. The habitus image of the beetle was taken using a Canon 5D Mark III camera in conjunction with a Canon MP-E 65mm f/2.8 1-5X Macro Lens, and a Canon MT-24EX Macro Twin Lite Flash was used as the light source. Images of the morphological details were produced using a Canon G9 camera mounted to an Olympus CX31 microscope under reflected or transmitted light. Zerene Stacker (version 1.04) was used for image stacking. All images were optimized and grouped into plates using Adobe Photoshop CC 2018.

The abdominal tergites and sternites are numbered following Chandler (2001) in Arabic (starting from the first visible segment) and Roman (reflecting true morphological position) numerals, e.g., tergite 1 (IV), or sternite 1 (III).

TAXONOMY

Cerochusa Yin & Nomura, 2012

Cerochusa Yin & Nomura in Yin *et al*., 2012: 66.

Type species: *Cerochusa cilioceps* Yin & Nomura (in Yin *et al*., 2012: 68).

Revised diagnosis: Body robust in form, with thick antennae and legs. Head roundly triangular; vertex convex medially, with U-shaped sulcus or impression connecting vertexal foveae; ocular canthi distinct, thick. Pronotum strongly transverse, with large spines at lateral sides, posterolateral corners spinose or angulate; disc with distinct median longitudinal sulcus, discal carinae weakly to strongly indicated, lateral longitudinal sulci present or absent. Elytra broad, transverse, truncate at bases and apices; each elytron with two distinct basal foveae; sutural striae complete, discal striae absent or distinct. Abdomen with tergite 1 (IV) twice length of

Manuscript accepted 05.08.2020
DOI: 10.35929/RSZ.0027

tergite 2 (V). Tergite 1 (IV) with complete or incomplete inner marginal carinae, outer marginal carinae complete, discal carinae short. Aedeagus with large and round basal capsule; basoventral projection prominent.

Composition: The genus contains two species (including the new species described here) distributed in southern China (Hainan) and Thailand (Loei, Nan, Chiang Mai).

***Cerochusa gesinae* Yin & Kleeberg, sp. nov.**
(Figs 1-2)

Type locality: Doi Suthep National Park, Chiang Mai, Thailand.

Type material: Holotype; ♂; THAILAND, 'North-Thailand, west of Chiang Mai, Doi Suthep National Park, Nov. 2019, Montha Than Waterfall, N18°49′01.6″, E98°55′32.7″ (695 m), 07.11.2019, leg. A. Kleeberg' (MNB).

Fig 1. Dorsal habitus of *Cerochusa gesinae* male. Scale bar: 0.5 mm.

Diagnosis: Male body length 2.5 mm. Vertex with Y-shaped sulcus; frontal-clypeal carina distinct. Pronotum with incomplete lateral longitudinal carinae. Discal striae of elytra strongly curved and carinate; posterior margin with dense long setae. Inner marginal carinae of tergite 1 (IV) oblique, extending to apical 2/3 of tergal length. Apices of tibiae with bunch of long setae. Aedeagus with broad and flat median and dorsal lobes; parameres fused to form membranous plate. Female unknown.

Description: Male. Body (Fig. 1A) length 2.52 mm (from anterior margin of clypeus to apex of abdomen); reddish brown. Head (Fig. 2A) roundly triangular, transverse, length from anterior margin of clypeus to head base (excluding occipital construction) 0.48 mm, width across eyes 0.61 mm; posterior margin of head notably concave at middle; vertex strongly transverse, with distinct Y-shaped sulcus at middle; frons and clypeus clearly demarcated by carina, anterior margin of frons angulate, pointed at middle. Eyes prominent, each composed of about 65 facets; ocular canthi thick, triangular. Length of antennae 1.03 mm, antennomeres 1 large, antennomeres 2-8 moniliform, antennomeres 9-10 successively wider, antennomeres 11 large and coniform. Pronotum (Fig. 2A) strongly transverse, trapezoidal, length along midline 0.47 mm, maximum width 0.79 mm; lateral margins with large spines near base, posterolateral corners distinctly angulate; median longitudinal sulcus broad, with short median carina at base; discal carinae moderately curved, extending from base to apical 2/5. Elytra (Figs 1A, 2B) broad, truncate both anteriorly and posteriorly, length along suture 0.70 mm, maximum width 0.90 mm; each elytron with two small but distinct basal foveae; sutural striae complete, discal striae strongly curved, carinate along inner margin, extending to apical 1/4; posterior margin with row of dense setae pointed posteriorly. Abdomen broadest at tergite 1 (IV), length along midline 0.81 mm, maximum width 0.80 mm; tergite 1 (IV) twice as long as tergite 2 (V), discal carinae short and slightly oblique; inner marginal carinae (Fig. 2B) oblique, extending to apical 1/3 of tergal length; tergites 2 (V) and 3 (VI) subequal in length, tergite 4 (VII) slightly longer than tergite 3. Sternite 7 (IX) membranous and paired. Legs short and robust, apices of tibiae with bunch of long setae. Aedeagus (Fig. 2C-E) moderately sclerotized, length 0.34 mm; basal capsule large and round; median lobe broad, truncate at apex; dorsal lobe flat, apically rounded and membranous; parameres fused, forming broad membranous ventral plate.
Female. Unknown.

Distribution: Thailand (Chiang Mai).

Etymology: The new specific epithet is dedicated to Gesine Kleeberg, wife of the second author, for her unselfish support to Andreas Kleeberg's entomological work.

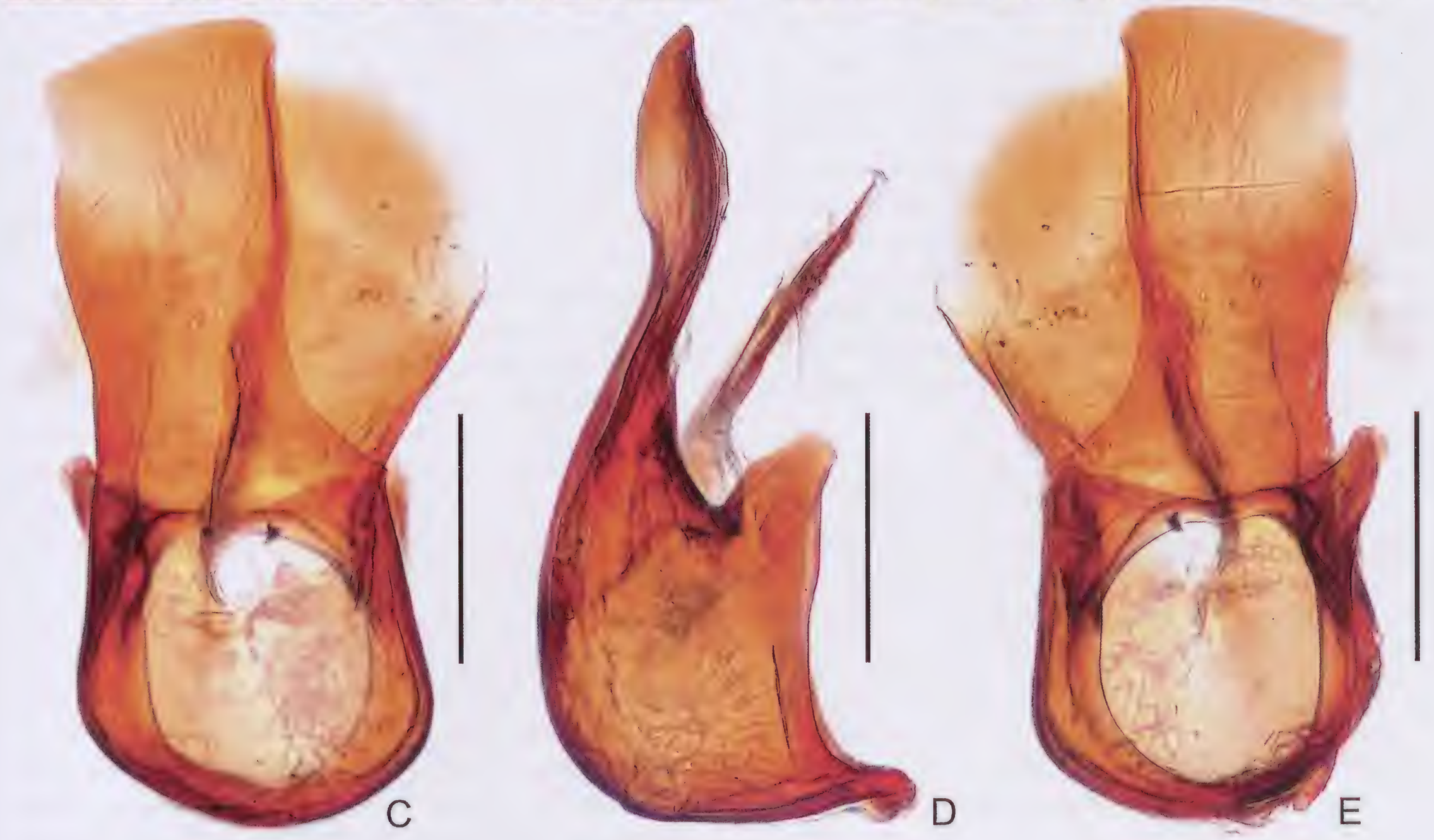


Fig. 2. Morphology of *Cerochusa gesinae* male. (A) Head dorsum and pronotum (B) Right elytron and base of abdomen (C-E) Aedeagus, in dorsal (C), lateral (D), and ventral (E) view. Scale bars: 0.3 mm in A, B; 0.1 mm in C-E.

Key to males

1 Head distinctly concave around vertexal foveae; frontal-clypeal carina slightly roundly curved at middle. Pronotum with distinct lateral longitudinal sulci. Elytra lacking discal striae; posterior margin lacking row of dense setae. Legs relatively slenderer; apices of tibiae lacking bunch of long setae. Tergite 1 (IV) with complete inner marginal carinae. Aedeagus with median lobe pointed at apex. (China: Hainan; Thailand: Loei, Nan) ..... ***C. cilioceps***

\- Head barely concave around vertexal foveae; frontal-clypeal carina pointed at middle. Pronotum lacking lateral longitudinal sulci. Elytra with distinct discal striae; posterior margin with row of dense setae. Legs relatively shorter; apices of tibiae with bunch of long setae. Tergite 1 (IV) with incomplete inner marginal carinae. Aedeagus with median lobe broad at apex. (Thailand: Chiang Mai) ..... ***C. gesinae*** sp. nov.

Notes: The small beetle was sieved near the upper part of the waterfall from material deposited near the banks, mainly wet leaves. The material obtained through a coarser beetle sieve (8 mm mesh size) was again sieved with a conventional kitchen sieve (2 mm mesh size) after several hours of drying.

ACKNOWLEDGMENTS

Two anonymous reviews commented on the draft manuscript which improved the paper. The present study was supported by the National Natural Science Foundation of China (No. 31872965), and the 'Phosphorus Project', Shanghai Municipal Science and Technology Commission, China (19QA1406600) awarded to ZWY.

REFERENCES

Chandler D.S. 2001. Biology, morphology, and systematics of the ant-like litter beetle genera of Australia (Coleoptera: Staphylinidae: Pselaphinae). *Memoirs on Entomology, International* 15: i-viii + 1-560.

Yin Z.-W., Li L.-Z. 2014. Description of *Bryantinus* gen. n. from Sarawak, and new distributional records for *Cerochusa cilioceps* in Thailand (Coleoptera: Staphylinidae: Pselaphinae). *PLoS ONE* 9 (11): e113474. doi:10.1371/journal.pone.0113474

Yin Z.-W., Nomura S., Li L.-Z. 2012. Redescription of *Ceroderma asperata* Raffray, and description of *Cerochusa cilioceps* gen. et sp. n. from Hainan, South China (Coleoptera, Staphylinidae, Pselaphinae). *Zootaxa* 3355: 62-68.

Revue suisse de Zoologie (September 2020) 127(2): 381-391 ISSN 0035-418

A mysterious dwarf: Suthepiidae nov. fam., a new harvestman family from mountains of northern Thailand (Arachnida: Opiliones: Laniatores)

Jochen Martens

Johannes Gutenberg-Universität, Institut für Organismische und Molekulare Evolutionsbiologie (iomE), D-55099 Mainz, Germany.
Senckenberg Research Institute, Arachnology, D-60325 Frankfurt am Main, Germany.
E-mail: martens@uni-mainz.de

Abstract: A new family of laniatorean harvestmen from northern Thailand is proposed, Suthepiidae fam. nov., which comprises one new genus and one new species, *Suthepia inermis* sp. nov. This family stands out by characters hitherto unknown or rarely recorded for Opiliones, and close relatives of this taxon are presently not discernible. Important characters are a short and compact penis with a massively enlarged distal part with a rich armament of sclerites and membranes which can be moved and everted by hemolymph pressure during mating; the pedipalp of males and females is without raptorial adaptations, i.e. elevated sockets (= apophyses) carrying strong distal spines are completely absent, therefore no prey capture basket is present; the male pedipalpal tarsus is enlarged and compressed, its dorso-distal double apophysis presumably contains a gland; the pedipalpal claw is weak, not longer or stronger than long hyaline setae on the dorso-distal apophysis of the tarsus. The only specimens presently known were found in litter of a few forested mountain stocks, between 450 m and 1400 m altitude. A brief overview of Southeast Asian laniatorean families is presented.

Keywords: Supra-generic systematics - genital morphology - new genus - new species - Southeast Asia.

INTRODUCTION

In the last twenty years the supra-generic classification of Opiliones has undergone dramatic changes, especially with the onset of molecular techniques. In the suborder Laniatores a number of clades were identified, several of them on the basis of molecular data, and subsequently defined by morphological characters; male genitalic characters played a major role. Many of the at first genetically defined lineages were assigned familial rank (Sharma & Giribet, 2011) and to a large extend the South American fauna is concerned, less so tropical Asian and African faunas (Kury, 2018). From 2000 onwards 20 family-level taxa were proposed, 16 in the suborder Laniatores, the majority of them from the Neotropics (Kury, 2018). The laniatorean fauna of Southeast Asia, however, remained relatively unchanged, with only few recently defined and/or described families. From mainland Southeast Asia, the Sunda Region and the Philippines only few families are known, and several of them contain largely unrevised subfamilies: Assamiidae, Biantidae, Podoctidae and Epedanidae. The Sandokanidae (previously Oncopodidae), with several recently established genera and many meticulously described species, present an agreeable exception (Martens & Schwendinger, 1998; Schwendinger & Martens, 1999, 2002; Schwendinger 2006). Recent additions to the Southeast Asian laniatorean fauna are the families Beloniscidae (Kury *et al.*, 2019), Tithaeidae and Petrobunidae (Sharma & Giribet, 2011), all defined on the basis of molecular genetics.

Here I present a previously unknown laniatorean species from the mountains of northern Thailand with unusual characters in male and female genitalia and in the male pedipalp. This species cannot be attributed to any extant opilionid genus or family and it is therefore here proposed as a representative of a new family-level taxon.

MATERIAL AND METHODS

Original line drawings were produced using a camera lucida attached to a Carl Zeiss research microscope. The photograph (Figs 1-2) was taken with a Nikon D810 attached to a SMZ 800 microscope. Measurements were taken by means of a micrometer disc attached to a Leitz stereomicroscope. Measurements of the pedipalps, the penis and the ovipositor were taken from the original drawings. All measurements are given in mm.

Manuscript accepted 11.08.2020
DOI: 10.35929/RSZ.0028

Abbreviations of morphological terms

Apo	apophysis
Cx	coxa
Fe	femur
la	lateral
Mt	metatarsus
Op anale	operculum anale
Op gen	operculum genitale
Pt	patella
Ta	tarsus
Ti	tibia
Tu	tubercle
Tu oc	tuber oculorum, ocularium
Tr	trochanter
I, II... XII	January, February… December

Museum acronyms

CJM Private collection of J. Martens, Mainz, Germany

MHNG Muséum d'histoire naturelle de Genève, Switzerland

SMF Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany

TAXONOMIC PART

Suborder Laniatores Thorell, 1876
Infraorder Grassatores Kury, 2003
Family Suthepiidae fam. nov.

Type genus: *Suthepia* gen. nov.

Included genera: Presently only one, the type genus.

Diagnosis: A family of the order Opiliones, suborder Laniatores, infraorder Grassatores with the following characters: Small species with less than two mm body length. Body surface of males and females rather smooth, without conspicuous tubercles, thorns or setae. Penis stout, distal half strongly enlarged laterally and dorso-ventrally, with complex hemolymph-pressure-driven system of sclerites and membranes, with an eversible prickly funnel in its interior, and with pairs of single setae plus pairs of groups of setae. Ovipositor short, with three pairs of long sub-apical setae on ventral side. Pedipalp in males and females smooth, without any apophyses carrying setae (i.e. not the raptorial type of laniatorean pedipalps); tarsus of males enlarged, bilaterally compressed, with scattered distal setae slightly longer than and as strong as tarsal claw.

Distribution: Presently only one species is known from mountains in northern Thailand.

Relationships: Suthepiidae is unique in possessing several presumably apomorphic characters of the male and female pedipalp (non-raptorial type of pedipalps) and in its male and female genital morphology (stout, distally markedly enlarged penis with a complex eversible system including a prickly funnel; ovipositor with three pairs of slender sub-apical setae only on ventral side). Currently no close relationships to any extant Southeast Asian laniatorean family is discernible (see Discussion).

Suthepia gen. nov.

Type species: *Suthepia inermis* sp. nov. by monotypy and designation.

Included species: Only the type species.

Diagnosis: As given for the family Suthepiidae: Pedipalps not forming a catching basket, completely devoid of any apophyses carrying spines in both sexes; pedipalpal tarsus in males compressed and deepened, with apical setae more or less as long and strong as tarsal claw. Male genital morphology highly complex, with a complicated set of sclerites and membranes, with an eversible prickly funnel and with a complex

Figs 1-2. *Suthepia inermis* sp. nov., body in dorsal view. (1) Female paratype. (2) Male holotype. Scale line 0.5 mm. Photograph by J. Severin.

arrangement of single setae and small groups of setae. Body largely unarmed, no conspicuous apophyses, thorns, granules or setae present. Small species with a body length of less than 2 mm.

Name: The Latinized generic name refers to one of the localities of the type material, the Doi Suthep, a mountain in northern Thailand. The gender is female.

Distribution: Currently known from four mountains of northern Thailand

***Suthepia inermis* sp. nov.**

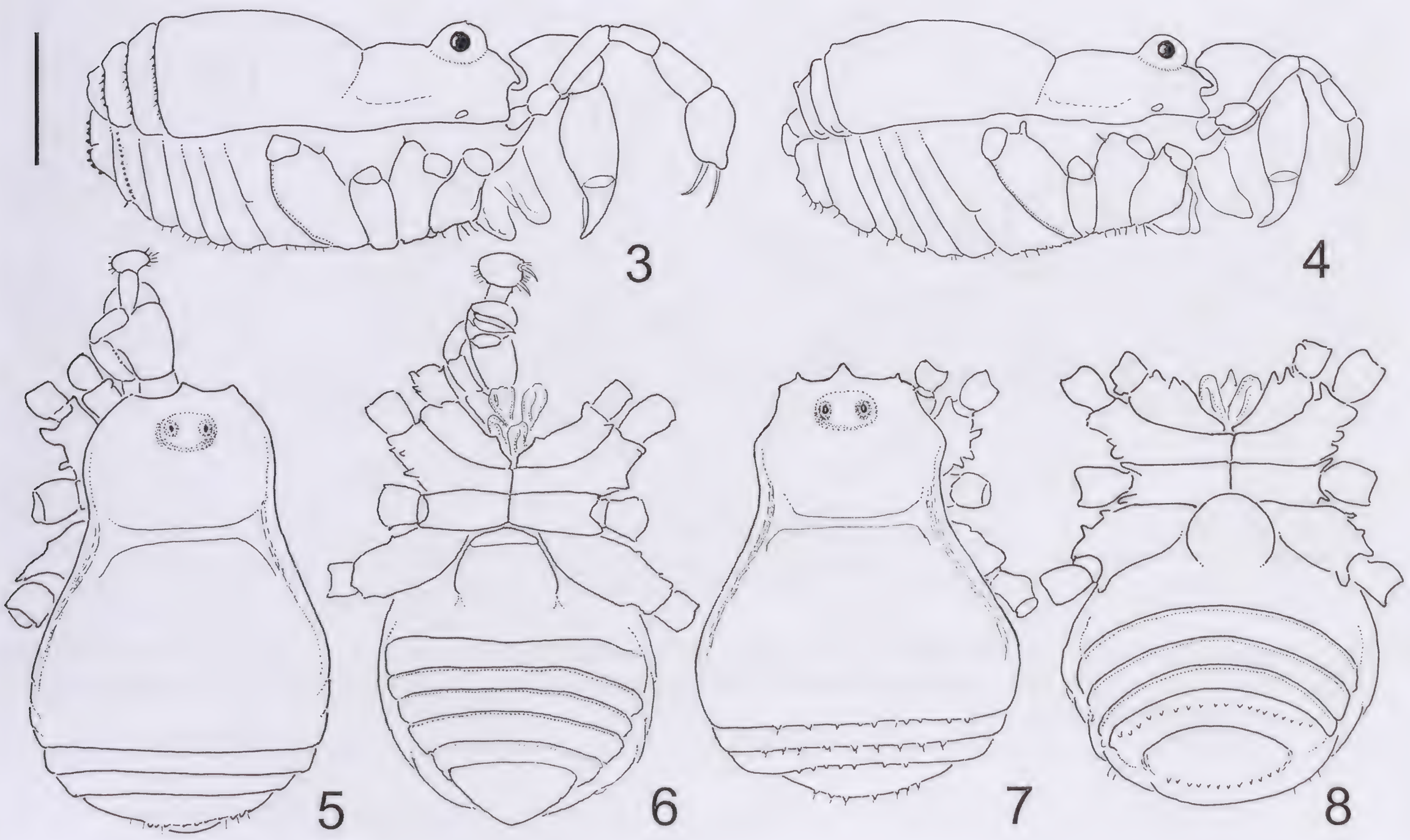
Figs 1-44

Holotype: SMF; male; THAILAND, Chiang Mai Province and District, Doi Suthep, 1300 m; J. Trautner and K. Geigenmüller leg.; 26.I.1989.

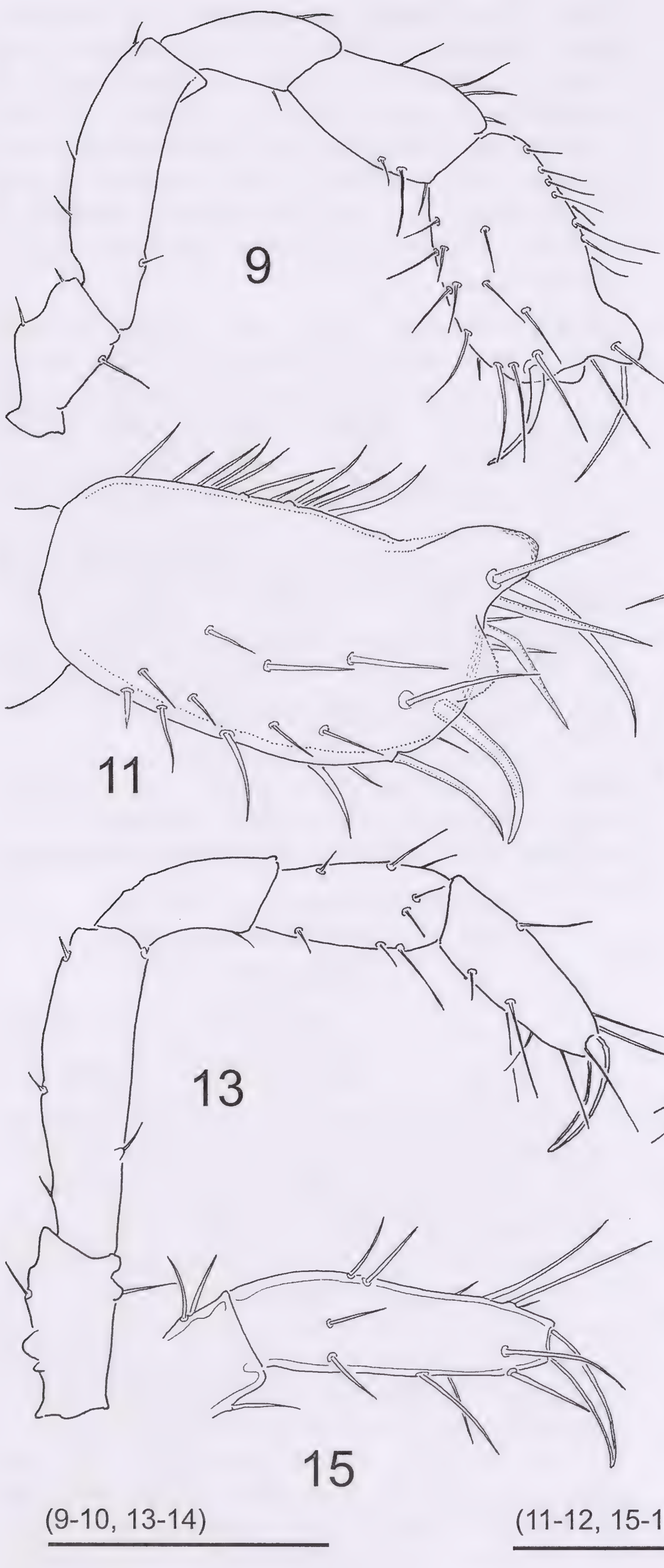
Paratypes: SMF; 1 female; collected together with the holotype. – MHNG; 1 male, 1 female; Chiang Mai Province, Chomthong District, Doi Inthanon, 1080 m; 24.II.1987. – MHNG; 2 females; Doi Inthanon, Pha Mon Valley, 910 m; 23.II.1987. – MHNG; 1 female; Chiang Mai District, Doi Suthep, 1150 m; 14.II.1987. – MHNG; 2 males, 2 females; Doi Suthep, 750 m, 17.X.1990. – MHNG; 1 female; Doi Suthep, 1090 m, 2.XII.1985. – MHNG; 10 males, 10 females; CJM; 2 males, 1 female; Doi Suthep, below Tham Rüsie (18°48'18"N 98°55'02"E), 1090 m, evergreen hill forest; 13.I.2011; sample THMY-10/10. – MHNG; 2 males, Chiang Mai Province, Chiang Dao District, Doi Chiang Dao, 840 m; 21.II.1986. – MHNG; 2 males, 4 females; Doi Chiang Dao, 450 m, 7.III.1987. – MHNG; 1 female; Doi Chiang Dao, 510 m; 22.IX.-25.X.1990 (in pitfall traps). – MHNG; 3 males, 2 females; Chiang Mai Province, Mae Taeng District, Huay Nam Dang, 1400 m; 17.XII.1990. All MHNG specimens leg. P.J. Schwendinger.

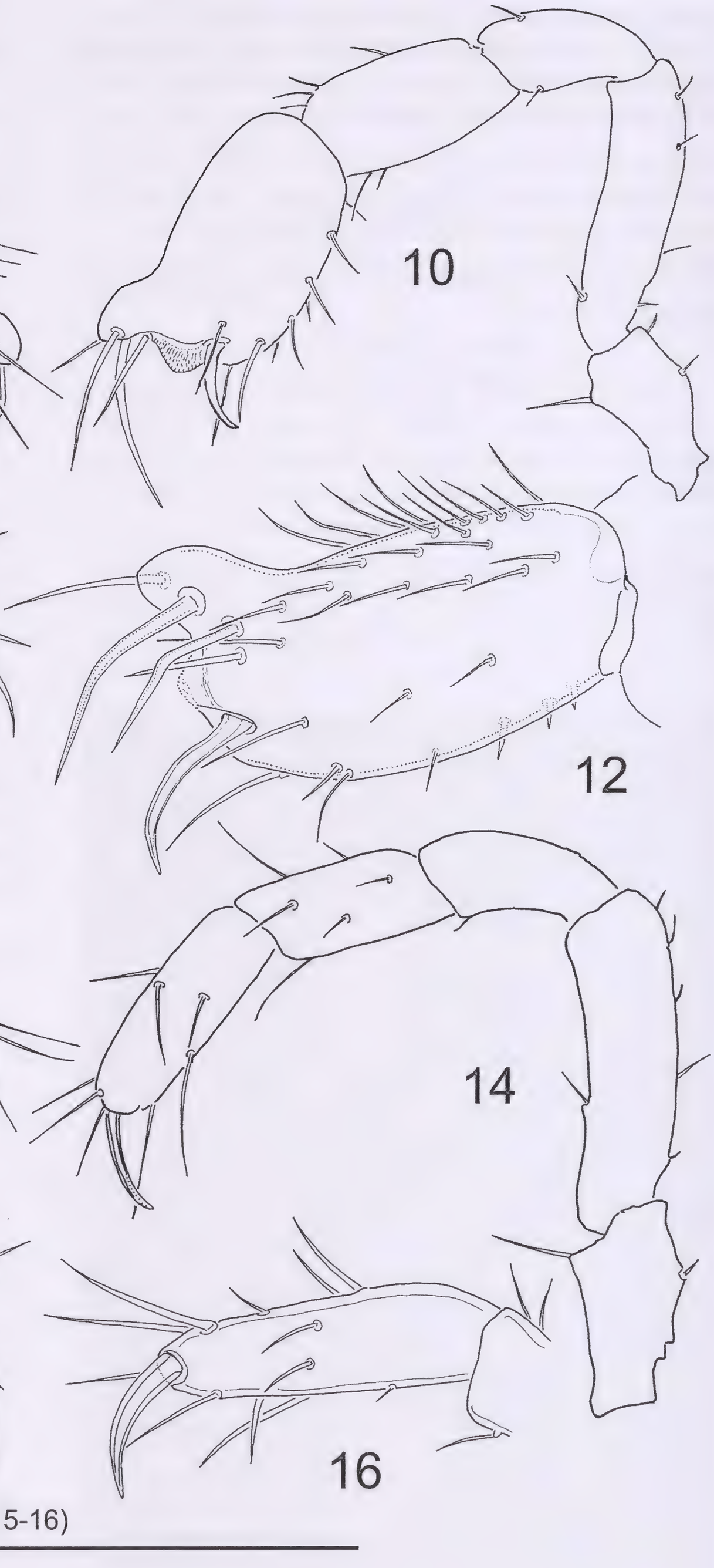
Diagnosis: A small species with a rather pyriform body, its dorsal side without tubercles or spines, with smooth surface; Tu oc low, broader than long, rounded. Chelicera strong, proximal article massively inflated in distal half. All articles of male pedipalp set with scattered setae, without apophyses and without spines; tarsus compressed and dorso-ventrally extended, with two rounded apophyses distally and dorso-distally, a smaller and a larger one, tarsal claw weak, not longer or stronger that longest apical seta. Female pedipalp generally as in male, but tarsus not enlarged and compressed, without apophyses, carrying a stronger claw.

Name: The Latin adjective "inermis" means without weapons and refers to the largely unarmed body of males and females, devoid of tubercles, spines and large sensilla.



Figs 3-8. *Suthepia inermis* sp. nov, male holotype (3, 5-6), female paratype. (4, 7-8). (3-4) Habitus, lateral view. (5, 7) Habitus, dorsal view, (6, 8) Habitus, ventral view. Scale line 0.5 mm.

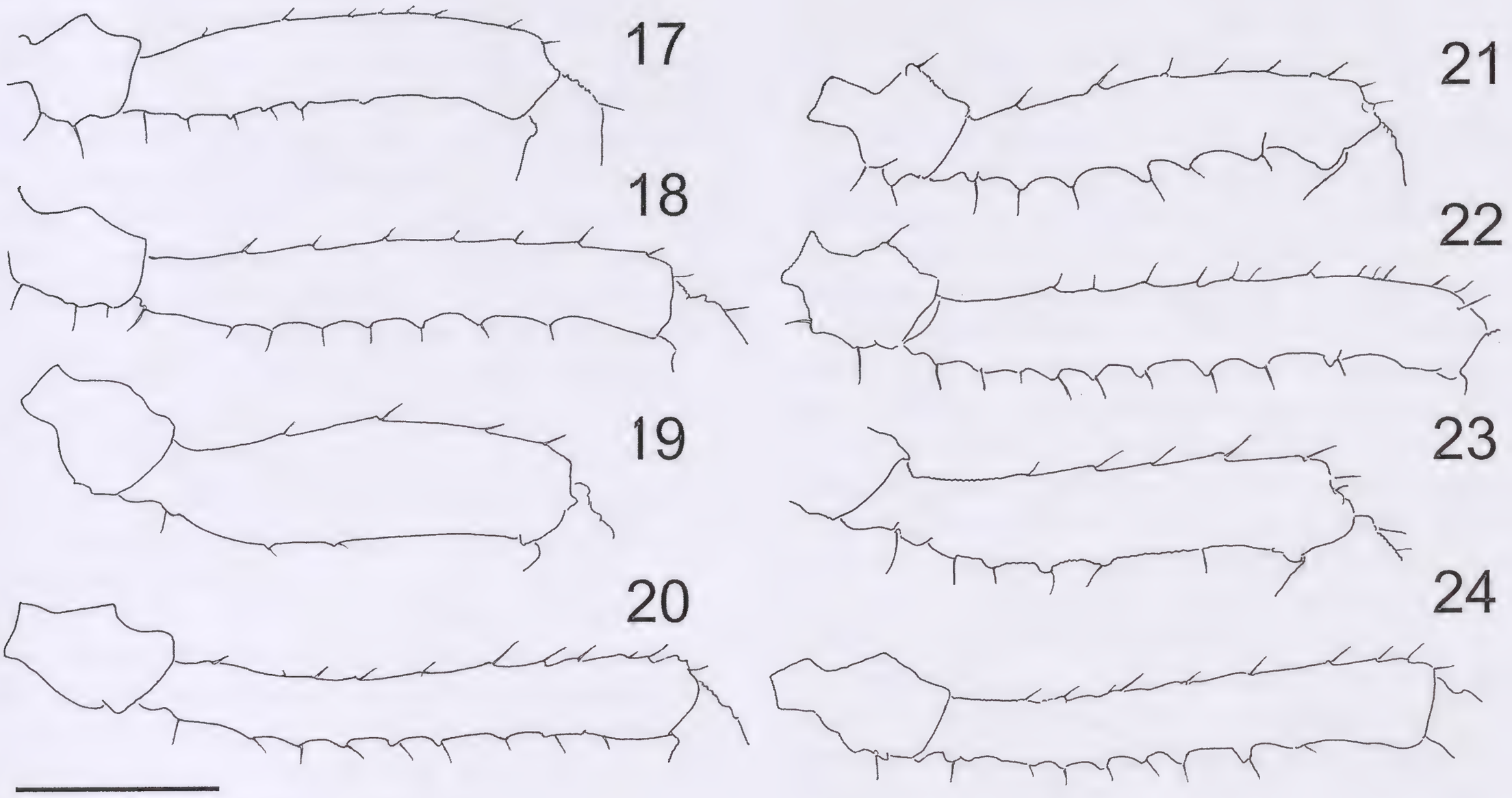


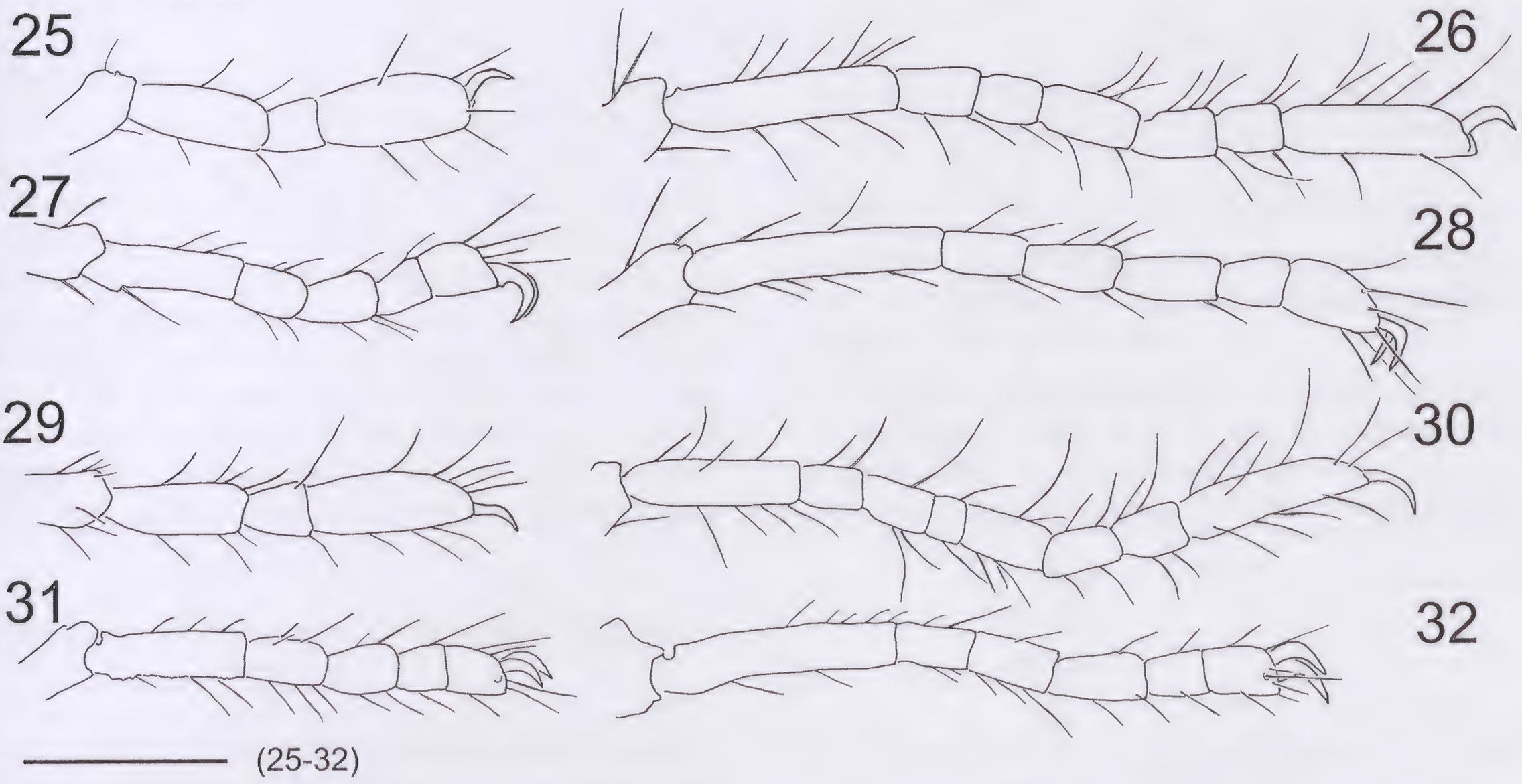


Figs 9-16. *Suthepia inermis* sp. nov., pedipalps of male holotype (9-12) and of female paratype (13-16). (9, 13) Right pedipalp, retrolateral view. (10, 14) Same, prolateral view. (11, 15) Right pedipalpal tarsus, retrolateral view. (12, 16) Same, prolateral view. Scale lines 0.3 mm.

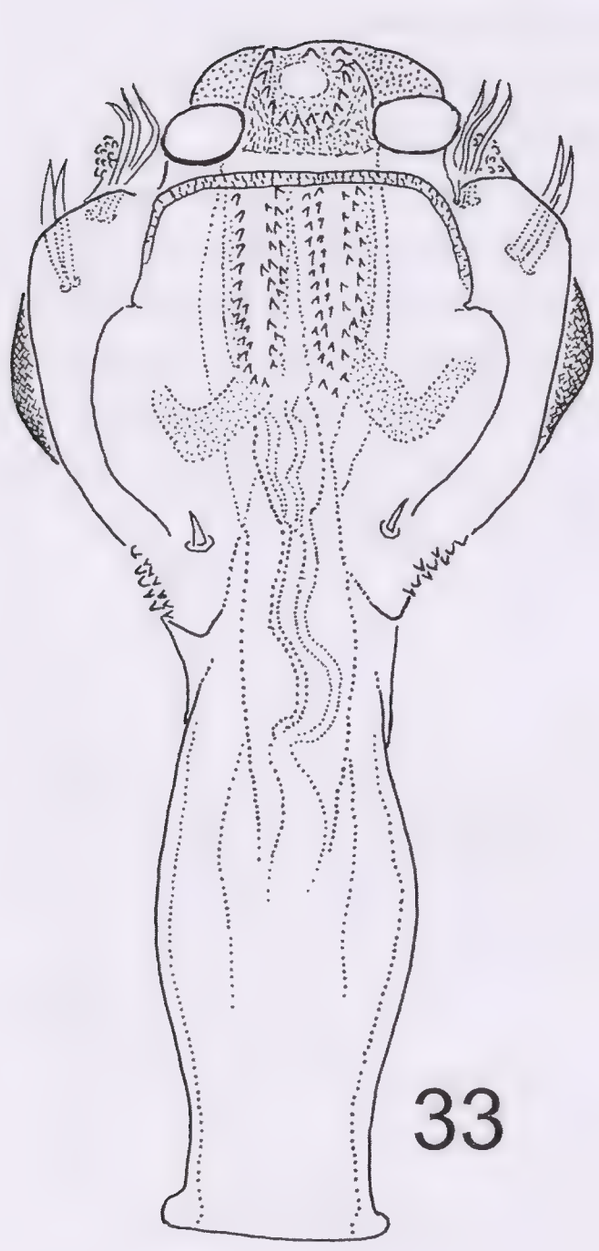
Description: MALE. *Body, dorsal side* (Figs 1, 5): Dark brown, without any light markings, pyriform (in dorsal view), prosomal part of dorsal scutum narrower than opisthosomal part, the latter continuously enlarged, broadest in proximal part. Fused opisthosomal tergites I-V without sulci. Free opisthosomal tergites I-III visible from above. Anterior margin of dorsal scutum with a small pointed projection; Tu oc low, dorsally rounded, separated from anterior margin of dorsal scutum by half its length; eyes small, with black surrounding ring. A row of minute tubercles on posterior margin of free opisthosomal tergite III; no strong setae; otherwise surface smooth but not shiny.

Body, ventral side (Fig. 6): On Cx I-II two relatively large elongate tubercles dorso-laterally; a row of minute tubercles on last free tergite and on Op anale. Op gen (Fig. 6) broader than long, slightly enlarged posteriorly, horizontally divided into a slim movable anterior part and a much larger immovable posterior part. Op gen continuous with the stigmatic segment.

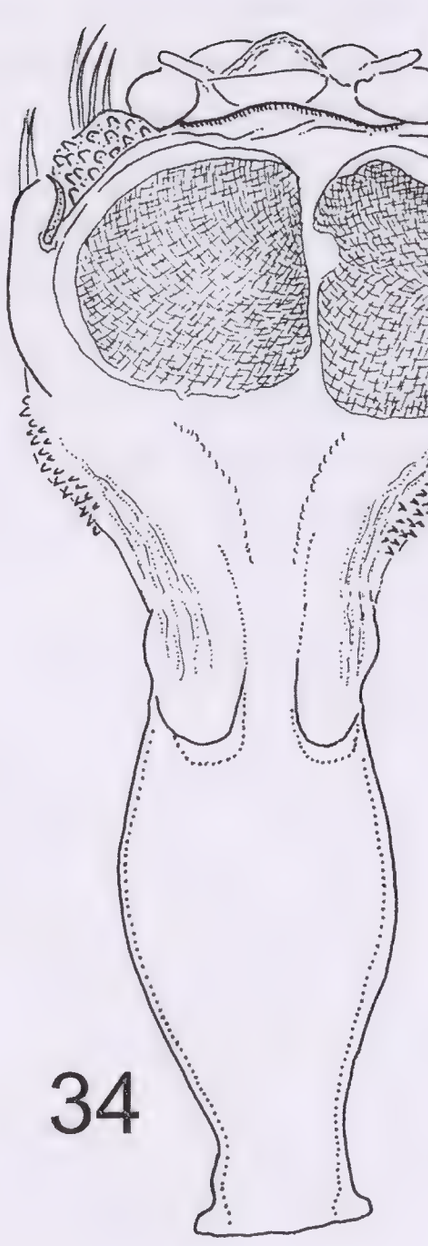




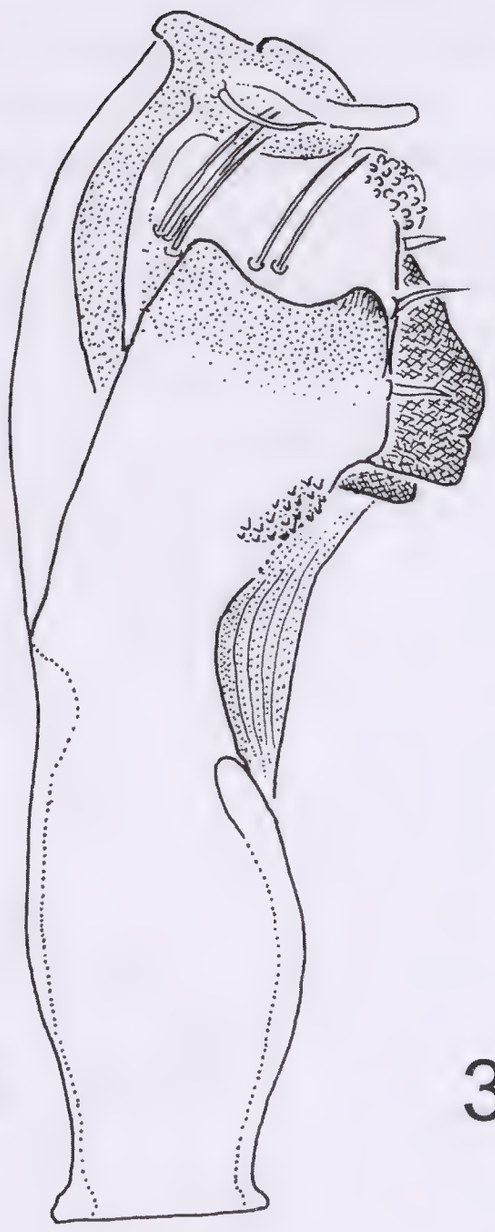
Figs 17-32. *Suthepia inermis* sp. nov., male paratype (17-20, 25-28), female paratype (21-24, 29-32). (17-24) Femora I-IV, retrolateral view. (25-32) Tarsi I-IV, retrolateral view. Scale lines 0.3 mm.



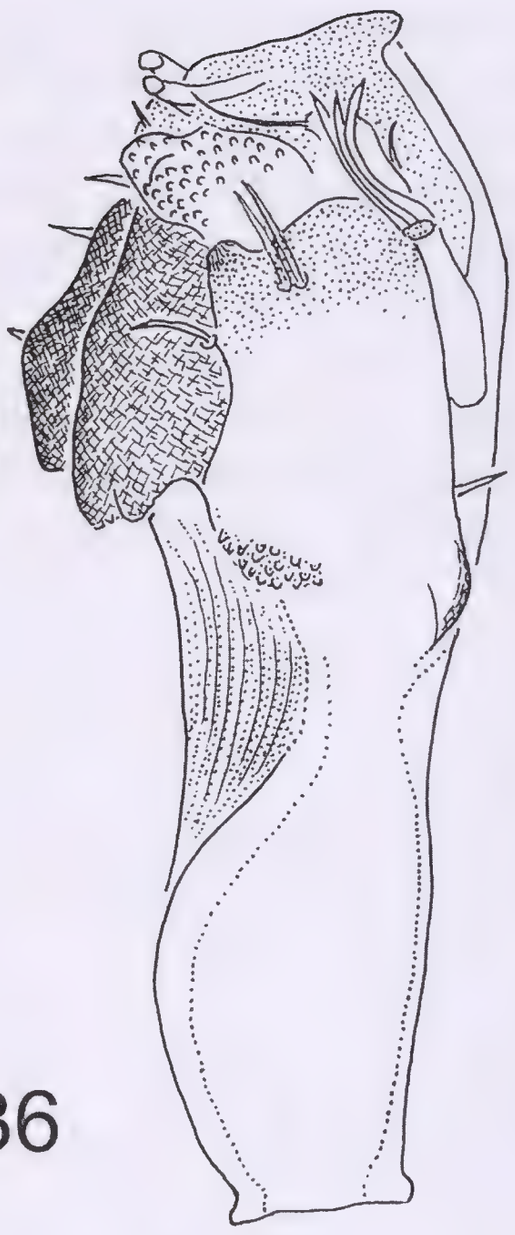
33



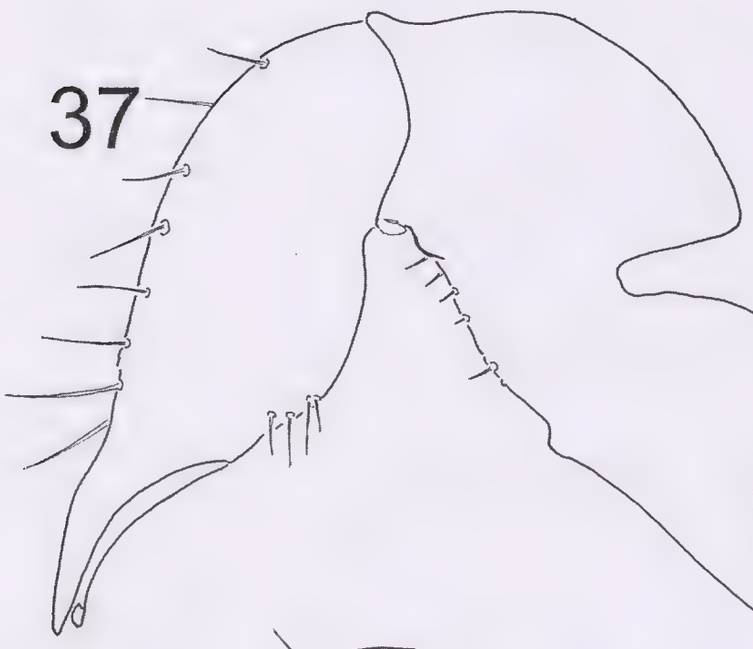
34



35

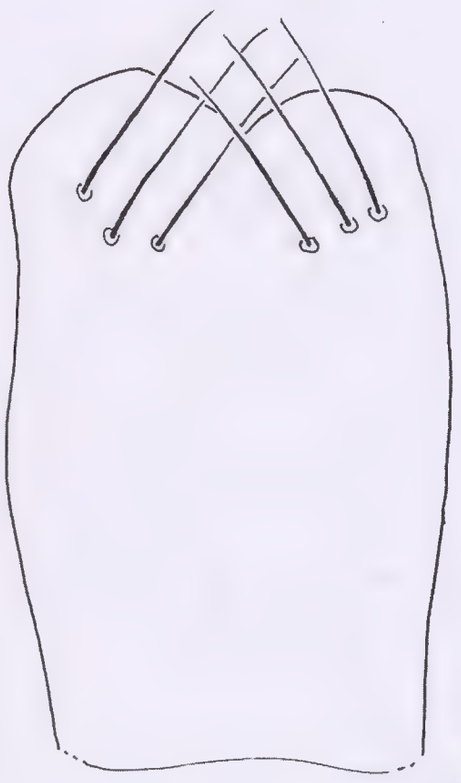


36

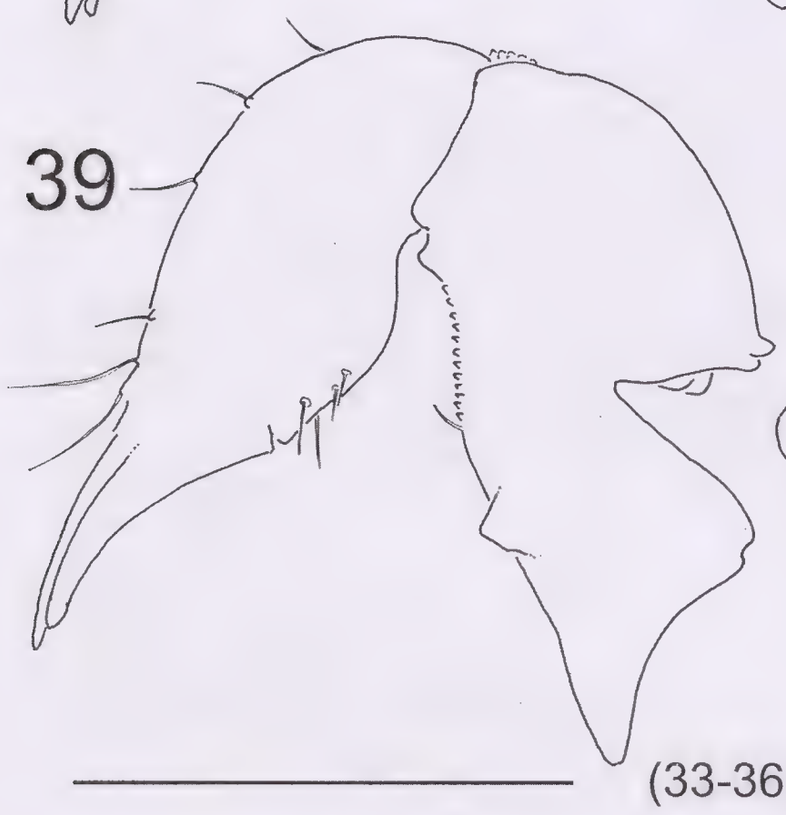


37

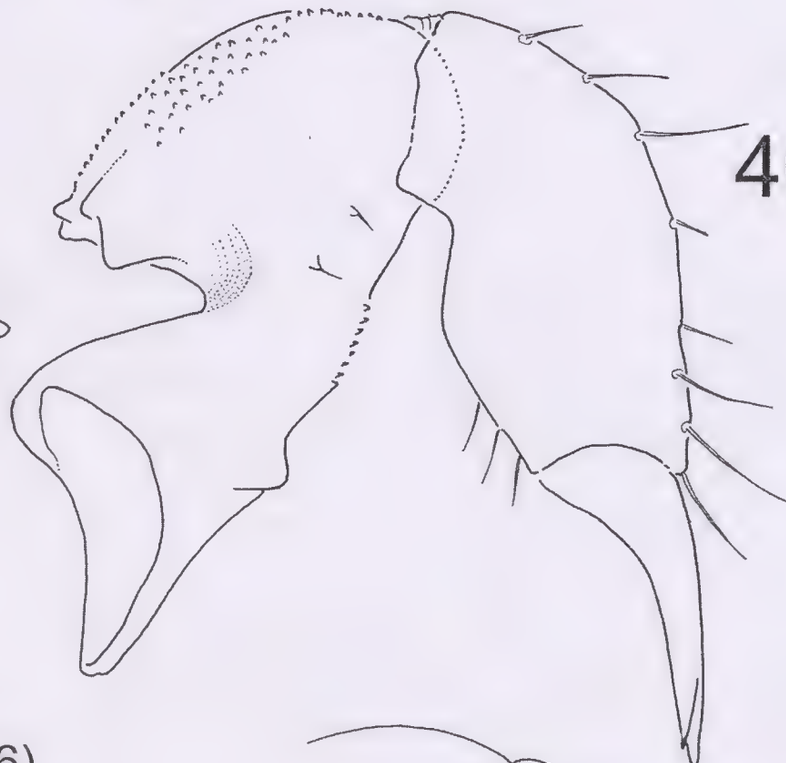
38



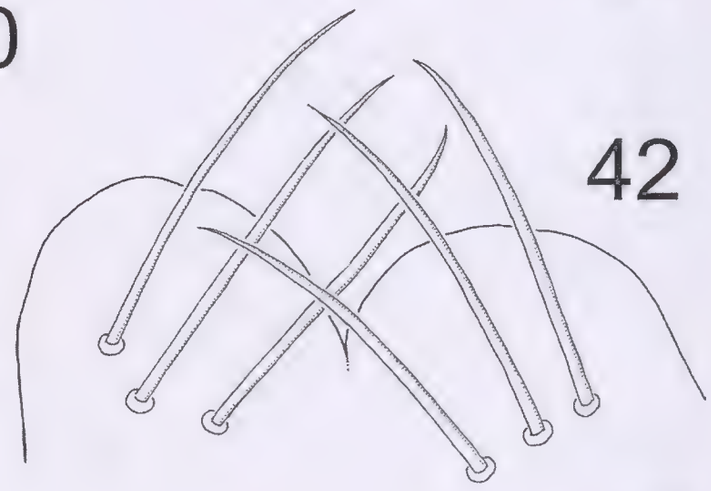
41



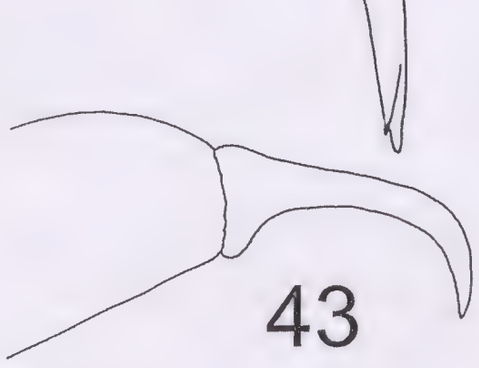
39



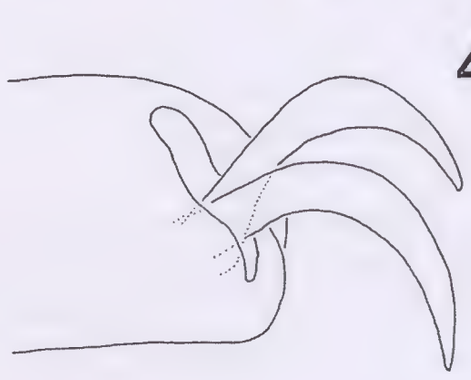
40



42



43



44

(33-36)

(42)

(37-41)

(43-44)

Figs 33-44. *Suthepia inermis* sp. nov., male holotype (33-38), female paratype (39-44). (33) Penis in dorsal view. (34) Same in ventral view. (35-36) Same in lateral view. (37, 39) Right chelicera, prolateral view. (38, 40) Same in retrolateral view. (41) Whole ovipositor, ventral view. (42) Distal part of ovipositor, ventral view. (43-44). (43) Single claw of leg I of female, retrolateral view. (44) Double claw of leg IV of female, retrolateral view. Scale lines: 0.3 mm (33-36; 37-41), 0.05 mm (42), 0.07 mm (43-44).

Chelicera (Figs 37-38): Basal article with a massive dorsal boss in distal half, its posterior margin drawn out and covering parts of posterior half of article and additionally covering a narrow anterior part of dorsal scutum in front of Tu oc; dorsal boss of basal article posteriorly ending in a pair of blunt Apo. Ventral side of basal article with a field of minute Tu ventrally. Second article slender frontally and ventrally, set with setae of various lengths, the longest ones close to base of distal article.

Pedipalp (Figs 9-12): Rather stout; Tr bulged dorsally, with one short seta, a longer one ventrally; Fe slightly curved ventrally, broadest in distal two thirds, with three minute setae dorsally, one ventro-basally (in lateral/ medial views); Pt with slender basis, enlarged distally; Ti quite massive, widening from basis to distal end, there slightly constricted to insertion of Ta; Ta markedly enlarged dorso-ventrally and markedly compressed, forming a paddle-shaped plate, dorso-distally with a large blunt Apo carrying two large setae (one on inner side, one on outer side, these slightly longer than tarsal claw) and distally with a smaller blunt Apo without setae; a rich setation on dorsal and inner side, less so on ventral and outer side; tarsal claw remarkably slender, markedly arched only in distal half. All setae and claw hyaline, not strongly sclerotized, strongest seta longer than and almost as strong as claw.

Legs (Figs 17-20, 25-28): Short, all articles with circular cross section, nearly unarmed except for few minute setae on low Tu mainly on ventral side of Fe I and III-IV (Figs 17-20); Fe (Fig. 19) and less so Pt and Ti of leg III markedly swollen; distalmost tarsal article of leg I and III slightly enlarged; a single unpectinate claw on Ta I-II (see Fig. 43 showing female), an unpectinate double claw on Ta III-IV (see Fig. 44 showing female).

Genital morphology (Figs 33-36): Penis highly complex, with complicated expandable and eversible parts, short and compact. A slight constriction above a broad base, then continuously widening and again becoming slightly constricted (in dorsal/ventral views), narrowest at about half-length of entire penis, then massively broadened, i.e. enlarged laterally and dorso-ventrally, forming a largely symmetrical, mushroom-like structure. Basal part of penis in la view similar to it in dorsal/ventral view but more bulged on ventral side. Distal half of penis with two large rounded plates protruding ventrally and causing an asymmetrical shape (Fig. 34). Distal part of penis highly complex and prone to unfolding by hemolymph pressure. Penis setation: Two groups of two and three slightly curved latero-distal setae pointing distad, two single short and strong setae flanking ventral plates laterally (Figs 34-36), two setae in distant position on dorsal side near basis of broadening of distal portion of penis (Fig. 33).
Discernible inner structures: An elongate prickly funnel in centre of broad distal part of penis with numerous denticles pointing distad, funnel apparently opening to centre of distal surface. Further inner structure containing seminal duct inside prickly funnel ending in distal stylus, its opening slightly below distal opening of funnel (in resting position). One pair of short tubular structures, each with rounded end at surface of penis, situated lateral to opening of funnel (Figs 33-34).
FEMALE: Similar to male in general habitus (Figs 4, 7-8), hardly any differences in chelicerae (Figs 39-40); Op gen smaller than in male, not horizontally divided into two parts, more rounded and nearly circular (Fig. 8). Pedipalpal Ta (Figs 13-16) markedly different from that of male, tapering from basis to distal end, cone-like, not compressed, with few short setae on all sides, longest at basis of claw; claw stronger and more compact than in male, slightly curved. Legs (Figs 21-24, 29-32) nearly identical to those of male in length and armature, only Fe III (Fig. 23) less inflated than in male. Pt and Ti of leg III not swollen, distalmost tarsal article of leg I only slightly swollen (Fig. 29), Fe I-IV ventrally with a few low Tu, most pronounced on Fe I and II (Figs 21-22).
Genital morphology (Figs 41-42): Ovipositor short, with two rounded distal lobes on right and left side; on each lobe three long setae crossing each other; all setae confined to dorsal side.

Measurements: Body length of males: 1.6-1.7 (n=11), of females: 1.55-1.8 (n=9). Pedipalp length of males (females in parentheses): Tr 0.15 (0.2), Fe 0.25 (0.25), Pt 0.2 (0.15), Ti 0.18 (0.18), Ta 0.3 (0.2). Penis length 0.7.
Leg articles of males and females: See Table 1.

Variation: Very little. Body size, body and leg armature and male pedipalp morphology of the 44 specimens examined largely invariable.

Distribution and ecology: The altitudinal distribution of this species ranges from 450 m to 1400 m and all collecting sites are in forested areas, mostly primeval, also near forest edges. Few specimens were collected

Table 1: Leg articles of males (females in parentheses)

	Tr	Fe	Pt	Ti	Mt	Ta	Total
I	0.2 (0.25)	0.6 (0.55)	0.2 (0.2)	0.4 (0.45)	0.65 (0.7)	0.6 (0.6)	2.65 (2.75)
II	0.25 (0.25)	0.8 (0.8)	0.35 (0.3)	0.8 (0.7)	0.9 (0.9)	1.05 (1.05)	4.15 (4.0)
III	0.25 (0.2)	0.6 (0.6)	0.25 (0.25)	0.45 (0.4)	0.5 (0.6)	0.6 (0.5)	2.60 (2.55)
IV	0.3 (0.25)	0.8 (0.8)	0.25 (0.3)	0.65 (0.7)	0.9 (0.9)	0.9 (0.95)	3.85 (3.9)

by hand, all others were sieved from forest litter. The collecting months are I, II, III and X, XII; all in the pre- or post-monsoon season when collecting (especially sieving) is easier due to reduced precipitation. Apparently this species is eurychronous.

The localities at only 450 m and 510 m altitude at the foot of the Doi Chiang Dao are exceptional from an ecological point of view. These are one of the few stands of evergreen forest in the lowlands of northern Thailand. In that seasonally dry region this forest type is usually found only above 1000 m. Apparently the rainwater which drains underground from the limestone slopes of Doi Chiang Dao (2175 m) resurfaces at the foot of the mountain and causes humid conditions all year round which in turn sustain an evergreen forest (P.J. Schwendinger, personal communication).

DISCUSSION

The opilionid fauna of Thailand

Our basic knowledge of opilionids of northern Thailand is relative good. A Thai-Danish expedition (led by Bertel Hansen and Birgit Degerbøl) collected there in 1958-1959 on Doi Suthep and Doi Inthanon, not far from the provincial capital Chiang Mai. Suzuki (1985a, b) worked on this rich material and described a number of new genera and species. In addition, in numerous, often voluminous papers Seisho Suzuki brought to our attention the rich fauna of Southeast Asian opilionids, always accompanied by meticulous drawings of the habitus, external and genital morphology showing a wealth of details (e.g., Suzuki, 1969a, b, and the two publications mentioned above). In this, he stands among the pioneers of Asian arachnology. For more than 35 years Peter J. Schwendinger has collected in northern Thailand as well as all over Thailand and Southeast Asia. To mention only his results concerning Opiliones, he discovered on Doi Inthanon the first Asian mainland representative of ortholasmatine Nemastomatidae (Schwendinger & Gruber, 1992), and his sandokanid studies (under Oncopodidae) led to an advanced level of knowledge on this group all over Southeast Asia (e.g., Martens & Schwendinger, 1998; Schwendinger, 2006; Schwendinger & Martens, 1999, 2002). He, too, helped to disentangle the mysterious cyphophthalmid *Fangensis leclerci* Rambla, 1994 and he identified several species of this genus overlooked by Rambla (Schwendinger & Giribet, 2005). Last but not least, he added considerable material to the present study.

Laniatorean families in Southeast Asia

Ten laniatorean families are known from Southeast Asia. All belong to the infraorder Grassatores, and all species in this group lack an internal penis muscle. All species in the Infraorder Insidiatores Loman, 1901 possess this inner organ. All flexible distal penis parts of Grassatores are moved by internal hemolymph pressure. Molecular analyses confirmed the monophyly of the Grassatores, but not that of the Insidiatores, their alleged sister group (Sharma & Giribet, 2011, 2014).

The Sandokanidae (previously Oncopodidae) is a widespread and species-rich, mostly Southeast Asian family with marginal populations in the southwestern Chinese province of Sichuan and on the southern fringes of the Nepal Himalaya. The phylogenetic placement of Sandokanidae within the Grassatores tree remains debatable (Sharma & Giribet, 2011).

Assamiidae is represented in Southeast Asia by several widespread subfamilies, with strongholds in the Himalayas westward to Kashmir (J. Martens, unpublished data). It is one of the two mainly Southeast Asian families which are represented by many species also in sub-Saharan Africa. Together with the sub-Saharan African Pyramidopidae, the Assamiidae form the superfamily Assamioidea (Sharma *et al.*, 2011).

Stygnommatidae is primarily a Neotropical family, but it is said to occur also in Indonesia and Malaysia (González, 2007). If this turns out to be correct, it would be the only laniatorean family with American-Asian connections. This is disputable.

Biantidae is fairly widespread in Southeast Asia (with a large unstudied material housed in the MHNG, P.J. Schwendinger, personal communication , and in the CJM from the Himalayas). An area along the Himalayan main range, which extends from southeastern Tibet over the Indian and Nepalese Himalayas to northern Pakistan, is especially rich in species (Martens, 1978, 2017; Gong *et al.*, 2018).

All Southeast Asian species are believed to belong to the nominate genus (Martens, 1978). The family is also widely distributed in India and in tropical Africa including Madagascar, in the latter area with a number of diverse genera and many species. Biantidae is sister to a lineage comprising the Stygnommatidae (Neotropical, Indonesia, Malaysia; see above) and the Samoidae, all three families plus the Biantidae and Podoctidae form the superfamily Samooidea.

Podoctidae occur all over Southeast Asia, with a concentration of species in the Philippines, from where large numbers of species are known.

Epedanidae is species-rich in Southeast Asia, with many genera and species described from Thailand.

Recent additions to the Southeast Asian laniatorean fauna are:

Beloniscidae was established by Kury *et al.* (2019) on a number of genera described but poorly and insufficiently defined by C.-F. Roewer. Two subfamilies are included, Beloniscinae and Buparinae.

Tithaeidae was separated from the Epedanidae by molecular analyses (Sharma & Giribet, 2011). The two genera *Tithaeus* Thorell, 1891 and *Metathitaeus* Suzuki, 1969 occur in Sundaland, i.e. the Thai-Malay Peninsula, Sumatra, Java and Borneo. The family was also reported

from northern Vietnam and southern China. More genera, established by C.-F. Roewer but not yet analysed, likely belong to this family too.

Petrobunidae is represented by a recently described genus and three species (Sharma & Giribet, 2011); it is known only from the Philippine islands of Palawan and Panay. An undescribed morphospecies was reported from Taiwan. The Japanese *Proscotolemon sauteri* Roewer, 1916 was recovered as nested within this family (Aharon *et al.*, 2020). Molecular sequence data do not support any superfamily-level placement of the Petrobunidae, although it clusters with other Southeast Asian families in all analyses and it is recovered as sister to the Epedanidae (Sharma & Giribet, 2011).

The case of the Suthepiidae

A number of traits characterize *Suthepia* gen. nov. and make it unmistakable; up to now it is not possible to attribute this genus, which belongs to the Grassatores, to any of the established Asian families. Even to affiliate it with one of the more or less soundly established superfamilies proves to be difficult. One superfamily, the Epedanoidea, which is not well supported genetically, harbors six apparently related families, the Epedanidae, Tithaeidae, Podoctidae, Sandokanidae and Petrobunidae, all more or less restricted to Southeast Asia. The recently established Beloniscidae were not included in that study (Sharma & Giribet, 2011). The Suthepiidae, primarily by geographical indication, may belong to this cluster. The families Biantidae and Assamiidae occur also in the Afrotropics, at least the Biantidae have larger numbers of genera and species in Africa than in Asia. The set of Neotropical families placed in the superfamilies Gonyleptoidea and Zalmoxoidea do not seem to have close affinities to *Suthepia* nov. gen.

External morphology; appendages: Unique characters of *Suthepia* gen. nov. are the spineless pedipalps in combination with an enlarged and compressed, sexual dimorphic male pedipalpal tarsus. Normally laniatorean pedipalps are equipped with numerous strong setae, often raised on small apophyses, to form an effective prey-catching basket, i.e. the raptorial type of pedipalps (Wolff *et al.*, 2016). The species of only few laniatorean genera and families lack this basket system, i.e. Sandokanidae in Asia (Schwendinger & Martens, 1999), the New Zealand Synthetonychidae (Martens, 1986), males of the triaenonychid genus *Ankarathrix* Lawrence, 1959 on Madagascar (Porto & Pérez-González, 2020) and furthermore a number of Podoctidae species from the Philippine island of Leyte (personal observation). The catching baskets can be much reduced to a hand-like structure formed only by the tibia and the tarsus, where strong setae remain. Examples are the Biantidae and several genera among the Epedanidae; other examples are figured in Porto & Pérez-González (2020). In all these cases conclusions on phylogenetic relationships cannot be drawn. Apparently several evolutionary lineages with reduced prey-catching baskets have evolved independently several times. The marked sexually dimorphic pedipalpal structures in *Suthepia* gen. nov., however, are unusual and paralleled only in the triaenonychid genus *Ankarathrix* from Madagascar in which male and female pedipalps are remarkably dimorphic in size and armament.

In males of *Suthepia* gen. nov. the pedipalpal tarsus is conspicuously compressed, paddle-shaped and equipped with a weak claw. There additionally is a remarkably large lobate protrusion (Apo) pointing dorso-distad, and a smaller one close to it pointing distad, both being the most prominent parts of the palpal tarsus. These characters are unique among Opiliones and have never been recorded before. I suspect that this structure contains a gland, but a tuft of fine hairs or setae is lacking. In Opiliones such a tuft is usually present on external structures which contain a gland, like the cheliceral modifications in the Nemastomatidae, Ischyropsalididae, Sabaconidae and others (Martens, 1973a; Martens & Schawaller, 1977). Moreover, this character is only present in the male sex, an indication that it plays a role in courtship behaviour. Glands in the palpal tarsus confined to the male sex are hitherto unrecorded for Laniatores, but they rarely occur in Palpatores, i.e. in the phalangiid genus *Himalphalangium* Martens, 1973 (Martens, 1973b).

Internal morphology; genital apparatus: Penial characters are important for defining opilionid families. Within genera and species of a given family basic characters in penial morphology and the mode of insemination are generally uniform (Martens, 1986, Macías-Ordóñez *et al.*, 2010). The stout penis of *Suthepia inermis* sp. nov., with a massive basal part and a strongly enlarged distal part, is markedly distinct from the penes of species of all other Old World and especially Asian opilionid families. However, the functionality of this complicated system of sclerites, membranes and scattered single setae or groups of setae is far from being fully understood. Apparently this system can be unfolded by hemoplymph pressure during courtships and copulation. This assumption is backed by the presence of a prickly funnel in the centre of the enlarged distal part of the penis. A prickly funnel is typical for penes of African and Asian Assamiidae (Bauer & Prieto, 2009; Kauri, 1961, 1985; Martens, 1977), and it was shown that the protruding funnel everts the end of the seminal duct, the stylus, to an exposed position (Martens, 1977). Prickly funnels are present also in the penes of New World Stygnopsidae (Mendes & Kury, 2007). Apparently such an inverted collar, which harbours the end part of the seminal duct, evolved several times in the Laniatores. Although it must be regarded as a highly apomorphic character, the presence of a prickly funnel consequently is not a reliable indicator for close relationships among opilionid families. Movable penis

parts, which in the resting position are retracted into the distal part of the penis trunk, are present also in Biantidae (Kauri, 1961, 1985; Martens, 1978), and in Epedanidae (Zhang & Martens, 2020). However, in these instances no invagination is present to harbour the distal part of the seminal duct. In Sandokanidae (formerly Oncopodidae), Tithaeidae and Stygnopsidae movable penis parts are also present, together forming the glans which is connected to the trunk by a membrane (the glans is slightly inverted in the sole sandokanid species of the genus *Martensiellus* Schwendinger, 2006) This system is movable by hemolymph pressure too.

ACKNOWLEDGEMENTS

Jürgen Trautner and Katrin Geigenmüller provided the first two specimens of the remarkable new species presented here. Peter J. Schwendinger (MHNG) contributed considerable additional material from his personal collection and he carefully edited the manuscript. Luis Acosta (Córdoba, Argentina) commented on an earlier version of the manuscript. With the help of Jean Severin I could add a photograph of the first two specimens. Over the years I was sponsored by the Feldbausch Foundation and the Wagner Foundation at the Fachbereich Biologie of Mainz University for fieldwork in Europe and Asia. I cordially thank all friends, colleagues and institutions.

REFERENCES

Aharon S., Ballesteros J.A., Crawford A.F., Friske K., Gainett G., Langford B., Santibánez-Lopéz C.E., Ya'aran S., Gavish-Regev S., Sharma P.P. 2020. The anatomy of an unstable node: A Levantine relict precipitates phylogenomic dissolution of higher-level relationships of the armored harvestmen (Arachnida: Opiliones: Laniatores). *Invertebrate Systematics* 33: 697-717.

Bauer C., Prieto C. E. 2009. Three new Assamiidae (Arachnida: Opiliones) from Cameroon, with a redescription of *Chilon robustus* and comments on related species. *Zootaxa* 2059: 1-22.

Gong X., Martens J., Zhang C. 2018. Two new species of *Biantes* Simon, 1885 from China and Malaysia (Opiliones: Laniatores: Biantidae). *Zootaxa* 4461: 587-599.

González A.P. 2007. Stygnommatidae Roewer, 1923. [pp. 229-232]. *In*: Pinto-da-Rocha R., Machado G., Giribet G. (eds), Harvestmen: The Biology of Opiliones. *Harvard University Press, Cambridge (Massachusetts) & London,* 597 pp.

Kauri H. 1961. Opiliones. *In*: Hanström B., Brinck P., Rudebeck G. (eds), South African animal life. Results of the Lund University Expedition in 1950-1951. *Uppsala, Almquist & Wiksell* 8: 9-197.

Kauri H. 1985. Opiliones from central Africa. *Zoologische Wetenschappen (Annales du Musée Royal de l'Afrique Centrale)* (Sci. zool.) 245: 1-168.

Kury A.B. 2003. Annotated catalogue of the Laniatores of the New World (Arachnida, Opiliones). *Revista Ibérica de Aracnología* vol. especial monográfico 1: 1-337.

Kury A.B. 2018. Familial nomina in harvestmen (Arachnida, Opiliones). *Binomina* 13: 1-27.

Kury A.B., Pérez-González A., Proud D. 2019. A new Indo-Malayan family of Grassatores (Arachnida, Opiliones, Laniatores). *Invertebrate Systematics* 33: 892-906.

Lawrence R.F. 1959. Faune de Madagascar. *Publications de l'Institut de Recherche Scientifique, Tananarive, Tsimbazaza* 9: 1-121.

Loman J.C.C. 1901 [for 1900]. Ueber die geographische Verbreitung der Opilioniden. *Zoologische Jahrbücher, Abteilung für Systematik, Ökologie und Geographie der Tiere* 13: 71-104, pls X-XI.

Macías-Ordóñez R., Machado G., Pérez-González A., Shultz J. 2010. Genitalic evolution in Opiliones [pp. 285-306]. *In*: Leonard J., Córdoba-Aguilar A. (eds), The evolution of primary sexual characters in animals. *Oxford University Press, New York*, 552 pp.

Martens J. 1973a. Feinstruktur der Cheliceren-Drüse von *Nemastoma dentigerum* Canestrini (Opiliones, Nemastomatidae). *Zeitschrift für Zellforschung* 136: 121-137.

Martens J. 1973b. Opiliones aus dem Nepal-Himalaya. II. Phalangiidae und Sclerosomatidae (Arachnida). *Senckenbergiana biologica* 54: 181-217.

Martens J. 1977. Opiliones aus dem Nepal-Himalaya III. Oncopodidae, Phalangodidae und Assamiidae (Arachnida). *Senckenbergiana biologica* 57: 295-340.

Martens J. 1978. Opiliones aus dem Nepal-Himalaya IV. Biantidae (Arachnida). *Senckenbergiana biologica* 58: 347-414.

Martens J. 1986. Die Großgliederung der Opiliones und die Evolution der Ordnung (Arachnida) [pp. 289-310]. *In*: Barrientos J.A. (ed.), Actas, X *Congreso Internacional de Aracnologia*, Jaca (España), septiembre 1986, vol. 1. *Instituto Pirenaico & Grupo de Aracnologia*, 428 pp.

Martens J. 2017. On *Starengovia* Snegovaya, a genus of Asian nemastomatines (Arachnida: Opiliones: Nemastomatidae). *Revue suisse de Zoologie* 124: 187-201.

Martens J., Schawaller W. 1977. Die Cheliceren-Drüsen der Weberknechte nach rasteroptischen und lichtoptischen Befunden (Arachnida: Opiliones). *Zoomorphologie* 86: 223-250.

Martens J., Schwendinger P. 1998. A taxonomic revision of the family Oncopodidae. I. New genera and new species of *Gnomulus* Thorell (Opiliones, Laniatores). *Revue suisse de Zoologie* 105: 499-555.

Mendes A.C, Kury A.B. 2007. Stygnopsidae Sørensen, 1932 [pp. 232-234]. *In*: Pinto-da-Rocha R., Machado G., Giribet G. (eds), Harvestmen: The Biology of Opiliones. *Harvard University Press, Cambridge (Massachusetts) & London,* 597 pp.

Porto W., Pérez-González A. 2020. Beauty under the mud: Soil crypsis and new species of the Malagasy genus *Ankaratrix* (Opiliones: Triaenonychidae: Triaenobuninae). *Zoologischer Anzeiger* 287: 198-216.

Rambla M. 1994. Un nouveau cyphophthalme du Sud-Est Asiatique, *Fangensis leclerci* n. gen. sp. (Opiliones, Sironidae). *Mémoires de Biospéologie* 21: 109-114, pls 1-3.

Roewer C.F. 1916. 7 neue Opilioniden des Zoolog. Museums in Berlin. *Archiv für Naturgeschichte*, *A* 81: 6-13.

Schwendinger P.J. 2006. A taxonomic revision of the family Oncopodidae VI. *Martensiellus*, a new genus from Borneo, and the discovery of a tarsal pore organ in Oncopodidae (Opiliones: Laniatores). *Zootaxa* 1325: 255-266.

Schwendinger P.J., Giribet G. 2005. The systematics of the south-east Asian genus *Fangensis* Rambla (Opiliones:

Cyphophthalmi: Stylocellidae). *Invertebrate Systematics* 19: 297-323.

Schwendinger P.J., Gruber J. 1992. A new *Dendrolasma* (Opiliones, Nemastomatidae) from Thailand. *Bulletin of the British Arachnological Society* 9: 57-60.

Schwendinger P.J., Martens J. 1999. A taxonomic revision of the family Oncopodidae. II. The genus *Gnomulus* Thorell (Opiliones, Laniatores). *Revue suisse de Zoologie* 106: 945-982.

Schwendinger P.J., Martens J. 2002. A taxonomic revision of the family Oncopodidae. III. Further new species of *Gnomulus* Thorell (Opiliones, Laniatores). *Revue suisse de Zoologie* 109: 47-113.

Sharma P.P., Giribet G. 2011. The evolutionary and biogeographic history of the armoured harvestmen – Laniatores phylogeny based on ten molecular markers, with the description of two new families of Opiliones (Arachnida). *Invertebrate Systematics* 25: 106-142.

Sharma P.P., Giribet G. 2014. A revised dated phylogeny of the arachnid order Opiliones. *Frontiers in Genetics.* doi: 10.3389/fgene.2014.00255

Sharma P.P., Prieto C.E., Giribet G. 2011. A new family of Laniatores (Arachnida: Opiliones) from the Afrotropics. *Invertebrate Systematics* 25: 143-154.

Suzuki S. 1969a. On a collection of Opilionids from Southeast Asia. *Journal of Science of the Hiroshima University, B1* 22: 11-77, pls 1-4.

Suzuki S. 1969b. Some Phalangids from Thailand. *Journal of Science of the Hiroshima University, B1* 22: 79-101, pl. 1.

Suzuki S. 1985a. A synopsis of the Opiliones of Thailand (Arachnida) I. Cyphophthalmi and Laniatores. *Steenstrupia* 11: 69-110.

Suzuki S. 1985b. A synopsis of the Opiliones of Thailand (Arachnida) II. Palpatores. *Steenstrupia* 11: 209-257.

Thorell T.T.T. 1876. Sopra alcuni Opilioni (Phalangidea) d'Europa e dell' Asia occidentale, con un quadro deì generi europei di quest' Ordine. *Annali del Museo Civico di Storia Naturale di Genova* (series 1) 8: 452-508.

Thorell T.T.T. 1891. Aracnidi di Pinang raccolti nel 1889 dai Sig.ri L. Loria e L. Fea. *Annali del Museo Civico di Storia Naturale di Genova* 30: 269-383.

Wolff J.O., Schönhofer A.L., Martens J., Wijnhoven H., Taylor C.K., Gorb S.N. 2016. The evolution of pedipalps and glandular hairs as predatory devices in harvestmen (Arachnida, Opiliones). *Zoological Journal of the Linnean Society* 177: 558-601.

Zhang C., Martens J. 2020. A taxonomic study on Epedanidae from Thailand including functional aspects of male genital morphology (Opiliones, Laniatores). *ZooKeys* 915: 25-58.

Revue suisse de Zoologie (September 2020) 127(2): 393-412 ISSN 0035-418

Hoverflies (Diptera: Syrphidae) of El Ventorrillo Biological Station, Madrid province, Spain: a perspective from a late twentieth century inventory

Daniel Lorenzo[1], Antonio Ricarte[1*], Zorica Nedeljković[1], José Luis Nieves-Aldrey[2] & Maria Ángeles Marcos-García[1]

[1] *Centro Iberoamericano de la Biodiversidad (CIBIO), Universidad de Alicante, Carretera de San Vicente, s/n, 03690 San Vicente del Raspeig, Alicante, Spain.*

[2] *Museo Nacional de Ciencias Naturales (C.S.I.C.). J. Gutiérrez Abascal 2, 28006 Madrid, Spain.*

* *Corresponding author: ricarte24@gmail.com*

Abstract: Temporal comparisons of a site's biodiversity depend on the availability of at least two asynchronous data sets on a bioindicator group. The Sierra de Guadarrama, a mountain range in central Spain has a high biodiversity and representative sites such as El Ventorrillo Biological Station (Madrid province) play an important role in research and monitoring of the Sierra biodiversity. Although unevenly and randomly, hoverflies of the Sierra de Guadarrama have been surveyed for decades, but never at El Ventorrillo. This important group of pollinators, aphid predators and bioindicators was sampled with a Malaise trap at El Ventorrillo from June 1989 to June 1990. A total of 51 species were identified (20 spp. of Eristalinae and 31 spp. of Syrphinae), 22 of which were new to the Sierra de Guadarrama and 17 to the Madrid province. The genera *Brachypalpus* and *Didea* were also new to the Madrid province. The Sierra de Guadarrama now has 126 species recorded and the Madrid province 150. Within the Sierra de Guadarrama, El Ventorrillo becomes the second locality in number of hoverfly species recorded after El Escorial (64 spp.). In the Malaise trap catch, hoverflies with zoophagous larvae had a higher representation than those of other guilds, both in species richness and abundance. The results provided here for El Ventorrillo represent a baseline for future biodiversity studies at this site with a similar experimental design, for example, to detect changes in hoverfly diversities along time.

Keywords: Eristalinae, Syrphinae, species richness, Sistema Central, Sierra de Guadarrama, Puerto Navacerrada, Malaise trap.

INTRODUCTION

Hoverflies are diverse, both in species and ecology, and occur in most habitats and regions (Marshall, 2012), pollinate many plants and control populations of other insects (Rotheray & Gilbert, 2011). They can be used as indicators of habitat integrity (Speight & Castella, 2005) and Global Change (Rotheray & Gilbert, 2011). Changing climate may have negative effects on hoverflies; for instance, in southern Europe, populations of saproxylic species (larvae dependent on moist microhabitats in trees, such as rot holes) are thought to decrease in the future under a projected warming climate (Marcos García & Ricarte, 2009). Diversity comparisons over time in accordance with available climatic data may help to understand the effects of climate change on biodiversity, but this requires that temporal series of data on diversity surveys are available.

Highlands represent areas of endemicity and high biodiversity levels within the Mediterranean Basin (García-Barros *et al.*, 2002; Reyero, 2002; Marcos-García *et al.*, 2007). The Sierra de Guadarrama, located in central Spain, is one of the Iberian locations with the most significant biodiversity (Lobo *et al.*, 2001; Lobo & Martín-Piera, 2002; Nieves-Aldrey *et al.*, 2003). For example, 1310 species of Hymenoptera are known to occur at El Ventorrillo (Madrid), a representative site within Sierra de Guadarrama, and in total 13000 insect species are estimated to occur at this single site (Nieves-Aldrey *et al.*, 2003). Its remarkable entomological diversity justifies the status of part of Sierra de Guadarrama as a national park since 2013. This Sierra is included mainly in the provinces of Madrid and Segovia, and most of the national park's surface belongs to the province of Madrid.

With 135 species, the province of Madrid has the third highest number of hoverfly species recorded for a Spanish province (Ricarte & Marcos-García, 2017; Grković *et al.*, 2019; Van Steenis *et al.*, 2020). Gil-Collado (1930) provided hoverfly records for 14 localities in the Sierra de

Manuscript accepted 14.08.2020
DOI: 10.35929/RSZ.0029

Guadarrama: Cercedilla, Collado Mediano, El Escorial, El Espinar, El Paular, Guadarrama, Los Molinos, Lozoya, Navacerrada, La Granja/San Ildefonso, San Rafael, Sierra de Guadarrama, Valle del Paular and Valsaín (Fig. 1). Later on, Peris (1962) described *Sericomyia hispanica* Peris, 1962 based on specimens from Cercedilla and La Granja reported by Gil-Collado (1930) as *Sericomyia lappona* (Linnaeus, 1758). Marcos-García & Louis (2001) also reported some hoverfly species from Sierra de Guadarrama. Marcos-García *et al.* (2007) treated unpublished material of *Merodon unguicornis* Strobl *in* Czerny & Strobl, 1909 from Cercedilla and designated a lectotype for *Merodon escorialensis* Strobl *in* Czerny & Strobl, 1909 from two syntypes collected at El Escorial. Van Steenis & Lucas (2011) reported *Pipizella lyneborgi* Torp Pedersen, 1971 based on specimens collected at El Escorial 2-3 years after its original description.

Within the Sierra de Guadarrama, some major insect groups are clearly understudied. For example, prior to this study only 27 species of five Dipteran families were known from El Ventorrillo (Kehlmaier, 2004, 2005; Kehlmaier *et al.*, 2019), with no records of bioindicator families such as hoverflies. Between 1988 and 1991, insects were systematically surveyed at El Ventorrillo, with more than a million specimens caught. Diptera was the most abundant group in these samples, with nearly half of the total number of collected specimens (Nieves-Aldrey *et al.*, 1991, 2003).

The main aim of the present study is to increase our knowledge on hoverfly distribution and phenology in the Sierra de Guadarrama by presenting a list of the hoverflies collected at El Ventorrillo with a Malaise trap over a one year period. The long term goal is to facilitate future comparisons of temporal diversities. The results

Fig. 1: Sierra de Guadarrama (Spain). El Ventorrillo is indicated with a red triangle. All labelled localities belong to Sierra de Guadarrama, although found outside the borders of the national park.

are also placed in the wider framework of the hoverfly diversity of the Sierra de Guadarrama and that of the province of Madrid.

MATERIAL AND METHODS

Study area

The Sierra de Guadarrama, with altitudes above 2000 m, belongs to the Sistema Central mountain range of Spain. El Ventorrillo (40°45'16.5"N 4°01'15.5"W, 1482 m) is a Biological Station of the 'Museo Nacional de Ciencias Naturales' (MNCN) (CSIC-Consejo Superior de Investigaciones Científicas), located on the south slope of Sierra de Guadarrama, in Cercedilla (Madrid province), about 60 km from the metropolis of Madrid (Nieves-Aldrey *et al*., 2003) (Fig. 1). The climate is subhumid Mediterranean tending to central European (Allué Andrade, 1987), with cold winters, possible freezes from September to June, 1000-1600 mm/year of precipitation, and a short, dry, and warm period in July-August ('Puerto de Navacerrada' as weather reference).

The area's vegetation is supra Mediterranean (Rivas Martínez, 1982), but the original vegetation has been largely replaced by plantations of *Pinus sylvestris* L. The vegetation at El Ventorrillo consists of a dense human-modified forest mainly of maples (*Acer pseudoplatanus* L.) and mountain elms (*Ulmus* sp.), but also linden, pine, cedar, fir, poplar, ash and holly. In the lower part of the Station, woodland is replaced by grasslands with roses and brambles. The vegetation at the forest/grassland edge consists of various shrubs such as *Cytisus*, *Crataegus*, *Rubus*, *Rosa*, *Cistus*, *Santolina*, *Juniperus*, and *Prunus*, while in close-by areas outside the Station some patches of *Quercus pyrenaica* Willd. with *Cistus* shrubs occur (Nieves-Aldrey *et al*., 2003) (Fig. 2).

Hoverfly sampling and identification

Insects were collected with a black Malaise trap of American design (Townes, 1972; Darling & Packer, 1988) (Fig. 2), from June 1989 to June 1990, except for the winter months of December to February, by José Luis Nieves-Aldrey & Carmen Rey-del-Castillo. The Malaise trap was placed in a humid site within a grassland/mix-forest edge (Nieves-Aldrey *et al*., 2003) (Fig. 2). Samples were collected in 75% alcohol and the trap was serviced weekly during a period of 240 days. Dipterans were

Fig. 2. El Ventorrillo in summer (Sierra de Guadarrama, Spain). Malaise trap placed in grassland/mix-forest edge.

extracted from the samples by José Luis Nieves-Aldrey and Carmen Rey-del-Castillo. Hoverflies were separated from the other Dipterans by Arabia Sánchez-Terrón in the 90's, and sent in plastic tubes with alcohol to the CIBIO Institute, University of Alicante, for identification. Specimens were dry mounted by Daniel Lorenzo, except for those of very abundant species that were stored in 70% alcohol. Some identified specimens were discarded due to their bad condition, but included in the results (see indications in the material examined).

Specimens were identified by Daniel Lorenzo with the assistance and supervision of Antonio Ricarte (Eristalinae), Zorica Nedeljković (Syrphinae), and M.A. Marcos-García. Keys and descriptions in the following publications were used for genus and species identifications: Violovitsh (1974), Goeldlin de Tiefenau (1976), Van Veen (2004), Vujić & Šimić (1999), Marcos-García *et al.* (2007), Nedeljković *et al.* (2013, 2015), Popović *et al.* (2015), Speight & Sarthou (2017), Van Steenis *et al.* (2017), and Van Steenis *et al.* (2020). The examined material is deposited in the 'Colección Entomológica de la Universidad de Alicante' (CEUA), CIBIO, University of Alicante, Spain.

The species recorded from El Ventorrillo are arranged alphabetically by genus and species (see 'Hoverfly records from El Ventorrillo'). The subfamily is indicated for each genus. Under each species, data on 'material examined' and 'guild' are presented. Ricarte & Marcos-García (2017), Van Steenis *et al.* (2017) and Grković *et al.* (2019) were used to find out which species were new to the Madrid province.

Guild, phenology, biogeography and conservation assessments

Ecological guilds, phenology, biogeographic features and conservation status of the hoverfly species found at El Ventorrillo were assessed. For the functional diversity assessment, species were classified in guilds according to larval trophic habits (Speight, 2020): zoophagous, phytophagous, saprophagous, and saproxylic (see 'Hoverfly records from El Ventorrillo' in results). Both saprophagous and saproxylic larvae feed on decaying organic materials. Saproxylic larvae develop in rot-holes, sap runs, tunnels in fallen wood, or under bark, i.e. they depend on trees while saprophagous larvae are found in decaying herbaceous vegetation of aquatic habitats, mud, dung, manure, and other similar breeding sites (Rotheray, 1994). Thus, sapoxylic species are placed here in a separate guild due to their specific association with usually mature or dead trees and their ecological and conservation implications in woodlands (Speight, 1989). When the larva is unknown, the guild is inferred from other congeneric species with known larvae.

The adult phenology of the collected species of Syrphidae at El Ventorrillo is represented on Table 1 in comparison with their phenology in Europe, taken from Speight (2020). For *Chrysotoxum volaticum* Séguy, 1961 the phenology in Europe follows Van Steenis *et al.* (2020). For the biogeographic assessment, the classification in European biogeographical zones of Speight *et al.* (2016) was used. An assessment of the conservation status of the hoverfly community at El Ventorrillo was also performed based on the threaten categories in Speight *et al.* (2016) for the European continent. In Speight *et al.* (2016) species are coded for a given threat category as 1, 2 or 3. If a species was coded in two categories, the category with highest code was chosen in our analysis. If Speight *et al.* (2016) used the same code twice for a given species (eg., '2, decreasing' + '2, unthreatened' for species A), the category implying a higher level of threat was selected (eg., species A 'decreasing'). *Chrysotoxum* sp. near *C. vernale* and *Chrysotoxum volaticum* were excluded from the biogeographic and conservation assessments due to lack of information.

Checklist of the Sierra de Guadarrama Syrphidae species

The hoverfly checklist for the Sierra de Guadarrama was elaborated in a table (Appendix), by revising all literature with records from localities in the Sierra de Guadarrama, i.e. Gil-Collado (1930), Peris (1962), Marcos-García & Louis (2001), Marcos-García *et al.* (2007), and Van Steenis & Lucas (2011). For references prior to 1930, see Gil-Collado (1930). All localities mentioned in the checklist belong to Sierra de Guadarrama, Madrid province, except for El Espinar, La Granja/San Ildefonso (any of these two names refer to the same locality), San Rafael, and Valsaín, which belong to the Sierra de Guadarrama, Segovia province (Fig. 1). In the table, 'Sierra de Guadarrama (gen.)' is used when the published locality for a bibliographic record is just 'Sierra de Guadarrama', except for *Volucella zonaria* (Poda, 1761) that is assumed to occur in Sierra de Guadarrama just due to its supposed widespread distribution (Gil-Collado, 1930; Ricarte & Marcos-García, 2017). In the checklist, all other species recorded from Madrid province are also listed (Ricarte & Marcos-García, 2017; Grković *et al.*, 2019; Van Steenis *et al.*, 2020), in such a way that a checklist of the Syrphidae from the Madrid province can be produced by excluding the species present on the Segovian side of Sierra de Guadarrama, but absent from the Madrid province.

RESULTS

Hoverfly records from El Ventorrillo

All examined specimens or lots of specimens share the following data: 'CEUA; Spain, Madrid, Sierra

de Guadarrama, El Ventorrillo Biological Station, 40º45'11.36"N 4º1'17.19"W; Leg.: J. L. Nieves-Aldrey & C. Rey-del-Castillo'.

BRACHYPALPUS Macquart, 1834 (Eristalinae) (New to Madrid)
***Brachypalpus laphriformis* (Fallén, 1816)** (New to Madrid)
Material examined: 1 male; 7-14.7.1989.
Guild: Saproxylic.

CALLICERA Panzer, 1806 (Eristalinae)
***Callicera macquarti* Rondani, 1844** (New to Madrid)
Material examined: 1 female; 1-7.5.1990.
Guild: Saproxylic (larva undescribed).

***Callicera rufa* Schummel, 1842**
Material examined: 1 female; 1-7.9.1989.
Guild: Saproxylic.

CHEILOSIA Meigen, 1822 (Eristalinae)
***Cheilosia gigantea* (Zetterstedt, 1838)** (New to Madrid)
Material examined: 1 female; 1-7.5.1990. – 1 female; 15-22.5.1990. – 1 female; 1-6.6.1990.
Guild: Phytophagous.

***Cheilosia laticornis* Rondani, 1857**
Material examined: 1 male; 11-20.4.1990. – 1 female; 1-6.vi.1990.
Guild: Phytophagous (larva undescribed).

***Cheilosia proxima* (Zetterstedt, 1843)** (New to Madrid)
Material examined: 1 female; 1-6.6.1990.
Guild: Phytophagous.

CHRYSOTOXUM Meigen, 1803 (Syrphinae)
***Chrysotoxum volaticum* Séguy, 1961**
Material examined: 3 males; 22-30.6.1989. – 3 males; 31.6–6.7.1989. – 3 males; 7-14.7.1989. – 3 males; 14-21.7.1989. – 1 female; 11-18.8.1989.
Guild: Zoophagous (larva undescribed).

***Chrysotoxum cisalpinum* Rondani, 1845**
Material examined: 1 male; 7-14.7.1989. – 2 males; 11-18.8.1989.
Guild: Zoophagous (larva undescribed).

***Chrysotoxum festivum* (Linnaeus, 1758)**
Material examined: 1 male; 7-14.7.1989. – 1 male; 14-21.7.1989.
Guild: Zoophagous (larva undescribed).

***Chrysotoxum intermedium* Meigen, 1822**
Material examined: 1 male; 9-16.6.1989. – 2 males; 7-14.7.1989. – 2 females; 15-22.5.1990. – 1 male; 1-6.6.1990.
Guild: Zoophagous (larva undescribed).

***Chrysotoxum latifasciatum* Becker, 1921**
Material examined: 1 male; 9-16.6.1989. – 1 male; 31.6-6.7.1989. – 2 males; 7-14.7.1989. – 1 male; 14-21.7.1989. – 1 female; 28.7-4.8.1989. – 1 female; 1-6.6.1990.
Guild: Zoophagous (larva undescribed).

***Chrysotoxum octomaculatum* Curtis, 1837**
Material examined: 1 male; 22-30.6.1989. – 2 males; 31.6–6.7.1989. – 6 males; 7-14.7.1989. – 6 males; 14-21.7.1989. – 2 females; 28.7-4.8.1989. – 1 male; 15-22.5.1990.
Guild: Zoophagous (larva undescribed).

***Chrysotoxum* sp. near *vernale* Loew, 1841** (New to Madrid)
Fig. 6C
Material examined: 1 male, 9-16.6.1989. – 1 female; 22-30.6.1989. – 1 female; 14-21.7.1989. – 1 female; 22-30.3.1990. – 1 female; 11-20.4.1990. – 1 male and 2 females; 15-22.5.1990. – 2 females; 23-31.5.1990. – 1 male and 3 females; 1-6.6.1990.
Guild: Zoophagous (larva undescribed).
Remarks: This species is currently being described by Nedeljković *et al.* (in press).

DASYSYRPHUS Enderlein, 1938 (Syrphinae)
***Dasysyrphus albostriatus* (Fallén, 1817)**
Fig. 6D
Material examined: 5 females; 9-16.6.1989. – 1 male; 22-30.6.1989. – 2 males and 1 female; 14-21.7.1989; 2 males and 2 females (all discarded); 25-31.8.1989. – 4 males and 2 females; 1-7.9.1989. – 1 female (discarded); 14-21.11.1989. – 1 male and 1 female; 21-28.9.1989. – 1 male; 23-31.5.1990.
Guild: Zoophagous.

***Dasysyrphus pauxillus* (Williston, 1887)** (New to Madrid)
Material examined: 1 male; 9-16.6.1989. – 4 males and 1 female; 23-31.5.1990. – 2 males; 1-6.6.1990.
Guild: Zoophagous (larva undescribed).

***Dasysyrphus tricinctus* (Fallén, 1817)** (New to Madrid)
Material examined: 1 male; 1-6.6.1990.
Guild: Zoophagous.

DIDEA Macquart, 1834 (Syrphinae) (New to Madrid)
***Didea intermedia* Loew, 1854** (New to Madrid)
Material examined: 1 female (discarded); 25-31.8.1989. – 1 female; 1-7.9.1989.
Guild: Zoophagous.

EPISYRPHUS Matsumura & Adachi, 1917 (Syrphinae)
***Episyrphus balteatus* (De Geer, 1776)**
Material examined: 1 male and 1 female; 7-14.7.1989. – 19 males and 9 females, 14-21.7.1989. – 1 male and 5 females; 20-28.7.1989. – 5 females (1 female discarded);

28.7-4.8.1989. – 2 females; 11-18.8.1989. – 1 female (discarded); 25-31.8.1989. – 1 male; 11-20.4.1990. – 2 males and 2 females; 15-22.5.1990. – 8 males and 1 female; 23-31.5.1990. – 1 male; 1-6.6.1990.
Guild: Zoophagous.

ERISTALIS Latreille, 1804 (Eristalinae)
***Eristalis arbustorum* (Linnaeus, 1758)**
Material examined: 1 male; 31.6-6.7.1989. – 1 male and 1 female; 7-14.7.1989. – 1 female; 14-21.7.1989. – 1 female; 28.7-4.8.1989.
Guild: Saprophagous.

***Eristalis horticola* (De Geer, 1776)**
Material examined: 1 female; 7-14.7.1989. – 2 males; 14-21.7.1989.
Guild: Saprophagous.

***Eristalis similis* (Fallén, 1817)**
Material examined: 2 males and 1 female; 14-21.7.1989.
Guild: Saprophagous.

***Eristalis tenax* (Linnaeus, 1758)**
Material examined: 1 male; 7-14.7.1989. – 1 male; 14-21.7.1989. – 1 male (discarded); 14-21.11.1989.
Guild: Saprophagous.

EUMERUS Meigen, 1822 (Eristalinae)
Eumerus consimilis Šimić & Vujić, 1996 (New to Madrid)
Material examined: 1 male and 1 female; 1-7.9.1989.
Guild: Phytophagous (larva undescribed).

***Eumerus sabulonum* (Fallén, 1817)**
Material examined: 1 male and 1 female; 9-16.6.1989.
Guild: Phytophagous (larva undescribed).

***Eumerus sulcitibius* Rondani, 1868** (New to Madrid)
Material examined: 1 female; 1-6.6.1990.
Guild: Phytophagous (larva undescribed).

EUPEODES Osten Sacken, 1877 (Syrphinae)
***Eupeodes corollae* (Fabricius, 1794)**
Material examined: 2 males and 16 females; 9-16.6.1989. – 7 females; 22-30.6.1989. – 2 males and 3 females (2 males and 2 females discarded); 31.6-6.7.1989. – 65 males and 87 females; 14-21.7.1989. – 5 males and 26 females; 20-28.7.1989. – 1 male and 54 females; 7-14.8.1989. – 12 males and 22 females (4 males and 10 females discarded); 28.7-4.8.1989. – 1 male and 16 females; 11-18.8.1989. – 3 females (discarded); 25-31.8.1989. – 1 female; 1-7.9.1989. – 1 female (discarded); 11-25.10.1989. – 1 female; 21-28.9.1989. – 1 female (discarded); 2-9.11.1989. – 2 females (discarded); 14-21.11.1989. – 1 male and 1 female; 11-20.4.1990. – 1 male and 10 females; 15-22.5.1990. – 1 male and 7 females; 23-31.5.1990. – 1 male and 1 female; 1-6.6.1990.
Guild: Zoophagous.

***Eupeodes latifasciatus* (Macquart, 1829)** (New to Madrid)
Material examined: 3 females; 9-16.6.1989. – 2 males and 1 female; 7-14.7.1989. – 3 females; 21-28.9.1989.
Guild: Zoophagous.

***Eupeodes luniger* (Meigen, 1822)**
Material examined: 2 females; 9-16.6.1989. – 1 female; 7-14.7.1989. – 2 females; 14-21.7.1989. – 1 male; 20-28.7.1989. – 1 male; 7-15.5.1990.
Guild: Zoophagous.

MELANOSTOMA Schiner, 1860 (Syrphinae)
***Melanostoma mellinum* (Linnaeus, 1758)**
Material examined: 2 males and 10 females; 9-16.6.1989. – 4 females; 22-30.6.1989. – 1 female (discarded); 31.6-6.7.1989. – 17 males and 6 females; 14-21.7.1989. – 13 males and 4 females; 20-28.7.1989. – 4 males and 5 females; 28.7-4.8.1989. – 7-14.8.1989. – 1 male; 11-18.8.1989. – 4 males and 5 females; 15-22.5.1990. – 30 males and 9 females; 23-31.5.1990. – 6 males and 7 females; 1-6.6.1990.
Guild: Zoophagous.

***Melanostoma scalare* (Fabricius, 1794)**
Material examined: 1 female; 9-16.6.1989. – 4 females; 22-30.6.1989. – 5 males and 10 females; 14-21.7.1989. – 1 male and 4 females; 20-28.7.1989. – 1 male and 2 females; 28.7-4.8.1989. – 2 males and 12 females; 7-14.8.1989. – 1 male and 1 female; 11-18.8.1989. – 1 female; 1-7.9.1989. – 1 male and 1 female; 15-22.5.1990. – 7 males and 10 females; 23-31.5.1990. – 1 female; 1-6.6.1990.
Guild: Zoophagous.

MELISCAEVA Frey, 1946 (Syrphinae)
***Meliscaeva auricollis* (Meigen, 1822)**
Material examined: 1 male; 22-30.6.1989. – 12 males; 7-14.7.1989. – 65 males and 13 females; 14-21.7.1989. – 1 male; 20-28.7.1989. – 3 males; 28.7–4.8.1989. – 1 female; 1-7.9.1989. – 1 male and 1 female; 21-28.9.1989. – 1 male; 23-31.5.1990. – 1 male; 1-6.6.1990.
Guild: Zoophagous.

MERODON Meigen, 1803 (Eristalinae)
***Merodon ibericus* Vujić *in* Popović *et al.*, 2015** (New to Madrid)
Material examined: 1 male and 2 females; 7-14.7.1989. – 3 males; 14-21.7.1989.
Guild: Phytophagous (larva undescribed).

***Merodon unguicornis* Strobl, 1909 *in* Czerny & Strobl, 1909**
Material examined: 1 female; 22-30.6.1989. – 2 females; 15-22.5.1990. – 1 female; 23-31.5.1990. – 3 females; 1-6.6.1990.
Guild: Phytophagous (larva undescribed).

***Merodon unicolor* Strobl *in* Czerny & Strobl, 1909**
Material examined: 4 males; 23-31.5.1990.
Guild: Phytophagous (larva undescribed).

NEOASCIA Williston, 1887 (Eristalinae)
***Neoascia podagrica* (Fabricius, 1775)**
Material examined: 2 females; 15-22.5.1990.
Guild: Saprophagous.

PARAGUS Latreille, 1804 (Syrphinae)
***Paragus bicolor* (Fabricius, 1794)**
Material examined: 1 female; 28.7-4.8.1989. – 1 female; 1-6.6.1990.
Guild: Zoophagous (larva undescribed).

***Paragus pecchiolii* Rondani, 1857** (New to Madrid)
Material examined: 1 male; 14-21.7.1989.
Guild: Zoophagous.

***Paragus strigatus* Meigen, 1822**
Material examined: 1 female; 9-16.6.1989.
Guild: Zoophagous (larva undescribed).

PARASYRPHUS Matsumura *in* Matsumura & Adachi, 1917 (Syrphinae)
***Parasyrphus punctulatus* (Verrall, 1873)** (New to Madrid)
Material examined: 1 male; 7-15.5.1990.
Guild: Zoophagous.

PELECOCERA Meigen, 1822 (Eristalinae)
***Pelecocera caledonica* (Collin, 1940)** (New to Madrid)
Material examined: 1 female; 21-28.9.1989. – 1 male; 1-6.6.1990.
Guild: Phytophagous (larva undescribed).

PLATYCHEIRUS Lepeletier & Serville, 1828 (Syrphinae)
***Platycheirus albimanus* (Fabricius, 1781)**
Material examined: 1 female; 14-21.7.1989. – 1 female; 20-28.7.1989.
Guild: Zoophagous.

***Platycheirus scutatus* (Meigen, 1822)** (New to Madrid)
Material examined: 1 female; 31.6-6.7.1989. – 1 female; 28.7-4.8.1989. – 2 males; 15-22.5.1990. – 1 male; 1-6.6.1990.
Guild: Zoophagous.

SCAEVA Fabricius, 1805 (Syrphinae)
***Scaeva pyrastri* (Linnaeus, 1758)**
Material examined: 1 female; 22-30.6.1989. – 1 female (discarded); 31.6-6.7.1989. – 1 male (discarded); 14-21.7.1989. – 1 female; 21-28.9.1989. – 1 female; 14-21.11.1989.
Guild: Zoophagous.

SPHAEROPHORIA Lepeletier & Serville, 1828 (Syrphinae)
***Sphaerophoria scripta* (Linnaeus, 1758)**
Material examined: 6 males and 9 females; 9-16.6.1989. – 11 males and 25 females; 22-30.6.1989. – 21 males and 39 females (discarded); 31.6-6.7.1989. – 50 males; 7-14.7.1989. – 156 males and 203 females; 14-21.7.1989. – 112 males and 165 females; 20-28.7.1989. – 70 males and 130 females (39 males and 66 females discarded); 28.7–4.8.1989. – 51 males; 7-14.8.1989. – 1 male and 3 females; 11-18.8.1989. – 1 female; 14-22.3.1990. – 2 females; 7-15.5.1990. – 3 males and 23 females; 15-22.5.1990. – 18 males and 35 females; 23-31.5.1990. – 9 males and 6 females; 1-6.6.1990.
Guild: Zoophagous.

SYRITTA Lepeletier & Serville, 1828 (Eristalinae)
***Syritta pipiens* (Linnaeus, 1758)**
Material examined: 1 female; 28.7-4.8.1989.
Guild: Saprophagous.

SYRPHUS Fabricius, 1775 (Syrphinae)
***Syrphus ribesii* (Linnaeus, 1758)**
Material examined: 1 female; 9-16.6.1989. – 2 females; 22-30.6.1989. – 1 female; 31.6-6.7.1989. – 1 male and 1 female; 7-14.7.1989. – 1 male and 1 female; 14-21.7.1989. – 1 male; 20-28.7.1989.
Guild: Zoophagous.

***Syrphus torvus* Osten Sacken, 1875**
Material examined: 2 females; 9-16.6.1989. – 1 male and 2 females; 14-21.7.1989. – 1 male; 20-28.7.1989.
Guild: Zoophagous.

***Syrphus vitripennis* Meigen, 1822**
Material examined: 1 female; 21-28.9.1989. – 1 male; 15-22.5.1990.
Guild: Zoophagous.

VOLUCELLA Geoffroy, 1762 (Eristalinae)
***Volucella elegans* Loew, 1862**
Material examined: 1 male; 7-14.7.1989.
Guild: Zoophagous (larva undescribed).

XANTHANDRUS Verrall, 1901 (Syrphinae)
***Xanthandrus comtus* (Harris, 1780)**
Material examined: 1 male; 14-21.7.1989.
Guild: Zoophagous.

XANTHOGRAMMA Schiner, 1860 (Syrphinae)
***Xanthogramma dives* (Rondani, 1857)** (New to Madrid)
Material examined: 1 female; 11-18.8.1989. – 1 female; 21-28.9.1989.
Guild: Zoophagous (larva undescribed).

Guilds, phenology, biogeography and conservation

In the Malaise trap samples, hoverflies of 51 species were collected, with 31 species of Syrphinae and 20 of Eristalinae (Table 1 and Appendix). Neither Microdontinae nor Pipizinae were collected. Zoophagous dominated both in species richness and abundance. In fact, a minimal proportion of individuals (below 3%) belonged to guilds other than zoophagous (Fig. 3).

Many species such as *Cheilosia laticornis* were recorded just from a short length of time within their flight period in Europe (Table 1). *Callicera macquarti* flies in June and September/October, but the female reported here was caught in early May. In a similar way, *Callicera rufa* is known to fly from mid May to August and the female recorded at El Ventorrilo was collected in early September. *Didea intermedia* was collected in September, one month after its flight period ends in Europe. For *Merodon unicolor* and *Chrysotoxum volaticum*, sub-populations from North Africa were also considered in the 'European' phenology. The phenology of *Chrysotoxum intermedium* is not provided since the taxonomy of this species is unresolved and several close taxa may exist under this name.

Most species collected at El Ventorrillo are typical for the Mediterranean zone of Europe (45 out of 51 spp.) closely followed by species occurring mainly in the Atlantic and Continental zones (40 spp. each). The lowest number of species are characterized having Macaronesian (16 spp.) and Arctic (12 spp.) distributions (Fig. 4). The majority of species recorded are unthreatened, four are decreasing

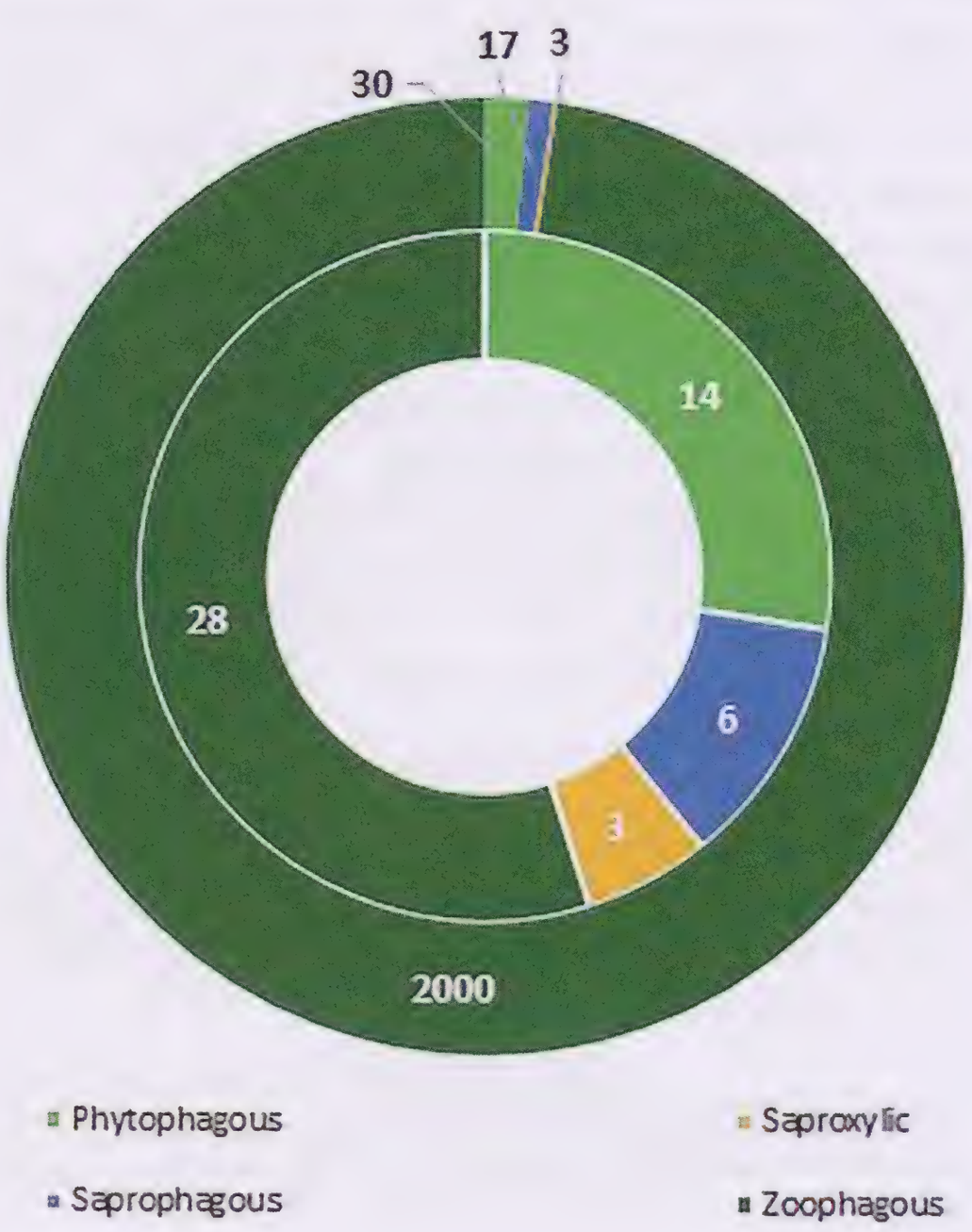


Fig. 3. Guild diversity of El Ventorrillo hoverflies. Inner circle, for species richness; outer circle, for abundance. 'Saproxylic' is used for saprophagous species depending on trees.

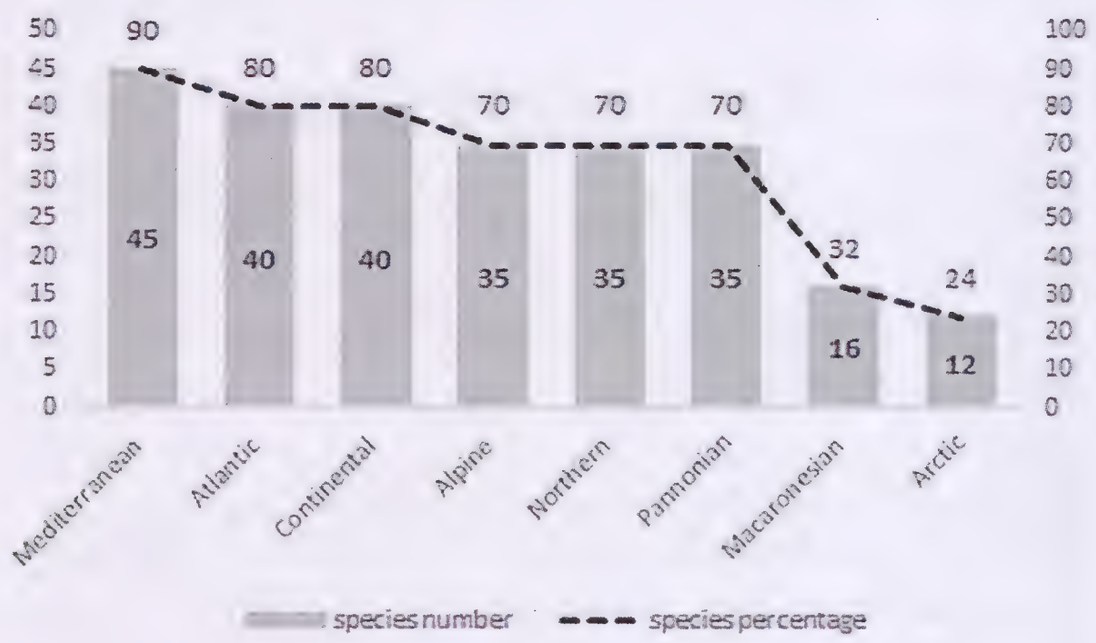
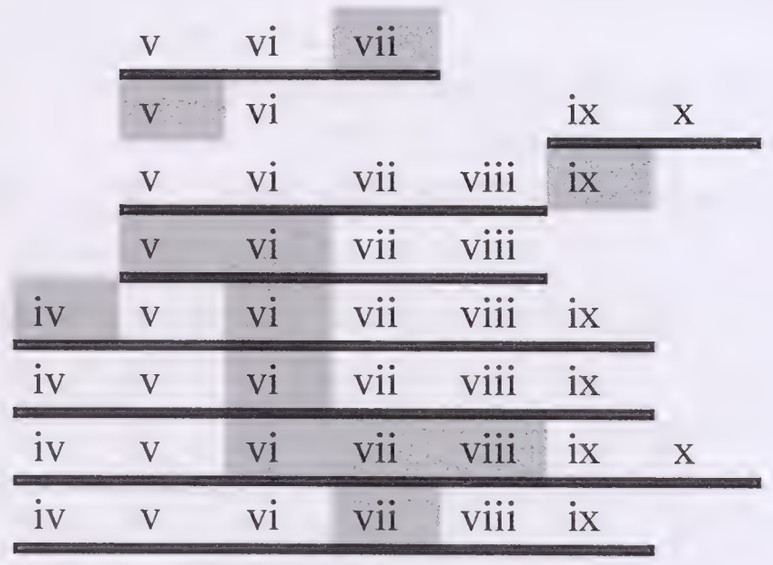


Fig. 4. Biogeographic diversity of El Ventorrillo hoverflies. Species known to be present in each biogegraphic zone of Europe, expressed both in species richness (within grey bar) and percentage (above bar) calculated from the total number of species found at El Ventorrillo. Notice that a species can be present in more than one biogeographic zone.

Table 1. Phenology of El Ventorrillo hoverflies. The flight period of adults in Europe is indicated with a black line while El Ventorrillo flight period is indicated in grey. Months: i, January; ii, February; iii, March; iv, April; v, May; vi, June; vii, July; viii, August; ix, September; x, October; xi, November; xii, December.

Eristalinae



Brachypalpus laphriformis
Callicera macquarti
Callicera rufa
Cheilosia gigantea
Cheilosia laticornis
Cheilosia proxima
Eristalis arbustorum
Eristalis horticola

Eristalis similis ii iii iv v vi vii viii ix x xi
Eristalis tenax ii iii iv v vi vii viii ix x xi
Eumerus consimilis v vi viii ix
Eumerus sabulonum v vi vii viii
Eumerus sulcitibius iv v vi vii viii ix
Merodon ibericus vi vii
Merodon unguicornis iv v vi vii
Merodon unicolor iv v vi vii viii ix
Neoascia podagrica iii iv v vi vii viii ix x
Pelecocera caledonica vi vii viii ix x
Syritta pipiens i ii iii iv v vi vii viii ix x xi xii
Volucella elegans v vi vii viii ix x
Syrphinae
Chrysotoxum volaticum v vi vii viii
Chrysotoxum cisalpinum v vi vii viii ix x
Chrysotoxum festivum v vi vii viii ix x
Chrysotoxum intermedium v vi vii
Chrysotoxum latifasciatum vi vii viii
Chrysotoxum octomaculatum v vi vii viii ix
Chrysotoxum sp. near *vernale* iii iv v vi vii
Dasysyrphus albostriatus iv v vi vii viii ix
Dasysyrphus pauxillus iv v vi vii
Dasysyrphus tricinctus iv v vi vii viii ix x
Didea intermedia v vi vii viii ix x
Episyrphus balteatus ii iii iv v vi vii viii ix x xi
Eupeodes corollae ii iii iv v vi vii viii ix x xi
Eupeodes latifasciatus v vi vii viii ix
Eupeodes luniger ii iii iv v vi vii viii ix x xi xii
Melanostoma mellinum iv v vi vii viii ix x
Melanostoma scalare iv v vi vii viii ix x
Meliscaeva auricollis ii iii iv v vi vii viii ix x xi
Paragus bicolor v vi vii viii
Paragus pecchiolii iii iv v vi vii viii ix x
Paragus strigatus iv v vi vii viii ix
Parasyrphus punctulatus iv v vi vii
Platycheirus albimanus iii iv v vi vii viii ix x xi
Platycheirus scutatus iv v vi vii viii ix x
Scaeva pyrastri ii iii iv v vi vii viii ix x xi
Sphaerophoria scripta iii iv v vi vii viii ix x xi
Syrphus ribesii iii iv v vi vii viii ix x xi
Syrphus torvus iii iv v vi vii viii ix x
Syrphus vitripennis iv v vi vii viii ix x
Xanthandrus comtus iv v vi vii viii ix x xi
Xanthogramma dives v vi vii viii ix

in number of populations or range at the European level (*Callicera rufa*, *Chrysotoxum cisalpinum*, *C. octomaculatum* and *Eumerus consimilis*), and two are probably threatened with extinction (*Callicera macquarti* and *Pelecocera caledonica*). The latter two species were represented by singletons or doubletons in the sample. *Chrysotoxum intermedium*, *C. latifasciatum*, *Merodon ibericus*, and *M. unguicornis* are regarded as data deficient in Europe.

Hoverfly fauna of Sierra de Guadarrama

With this study, 21 species are added to the checklist of the hoverflies of the Sierra de Guadarrama that is updated now to a total of 126 species (see Appendix). The genera *Brachypalpus*, *Didea*, *Dasysyrphus*, *Neoascia*, *Parasyrphus*, *Syritta*, and *Xanthandrus* are reported for the first time from Sierra de Guadarrama. Peris (1962) excluded *S. lappona* from the Spanish fauna of *Sericomyia*, but apparently he did not examine the material of *S. lappona* from El Escorial reported by Gil-Collado (1930). Thus, we retain *S. lappona* in the Sierra de Guadarrama checklist until this genus is revised in the Iberian Peninsula. The record of *Chrysotoxum bicinctum* (Linnaeus, 1758) from Cercedilla is likely to be a misidentification of *C. volaticum* but we retain *C. bicintum* in the Sierra de Guadarrama – and Madrid – checklist until the material from Cercedilla is revised. Although *Syritta pipiens* is one of the most common hoverflies in Spain (Gil-Collado, 1930; Ricarte & Marcos-García, 2017) and it is most likely to occur everywhere in Sierra de Guadarrama, the specimen reported here represents the first documented record from Sierra de Guadarrama. In the Malaise trap inventory discussed here, 40% of the species found in the Sierra de Guadarrama are represented.

Within the Sierra de Guadarrama, El Escorial is the locality with the highest number of species recorded (64 spp.), followed by El Ventorrillo (51 spp.), both in Madrid province. Valle del Paular and Navacerrada, also in Madrid, are clearly under-recorded (one species each). La Granja/San Ildefonso is the Segovian locality in Sierra de Guadarrama with the highest number of species recorded, although the absolute number is still low (19 spp.) (Fig. 5). In 11 out of 14 localities of Sierra de Guadarrama, 50% or more of the collected species are eristalines, but the only locality sampled with a systematic technique, El Ventorrillo, has a higher proportion of syrphine species than eristaline species (61% vs. 39%). The hoverfly diversities in all the mentioned localities (Fig. 5) are not comparable with each other due to different sampling efforts and techniques used by the different collectors over time. However, Fig. 5 is still

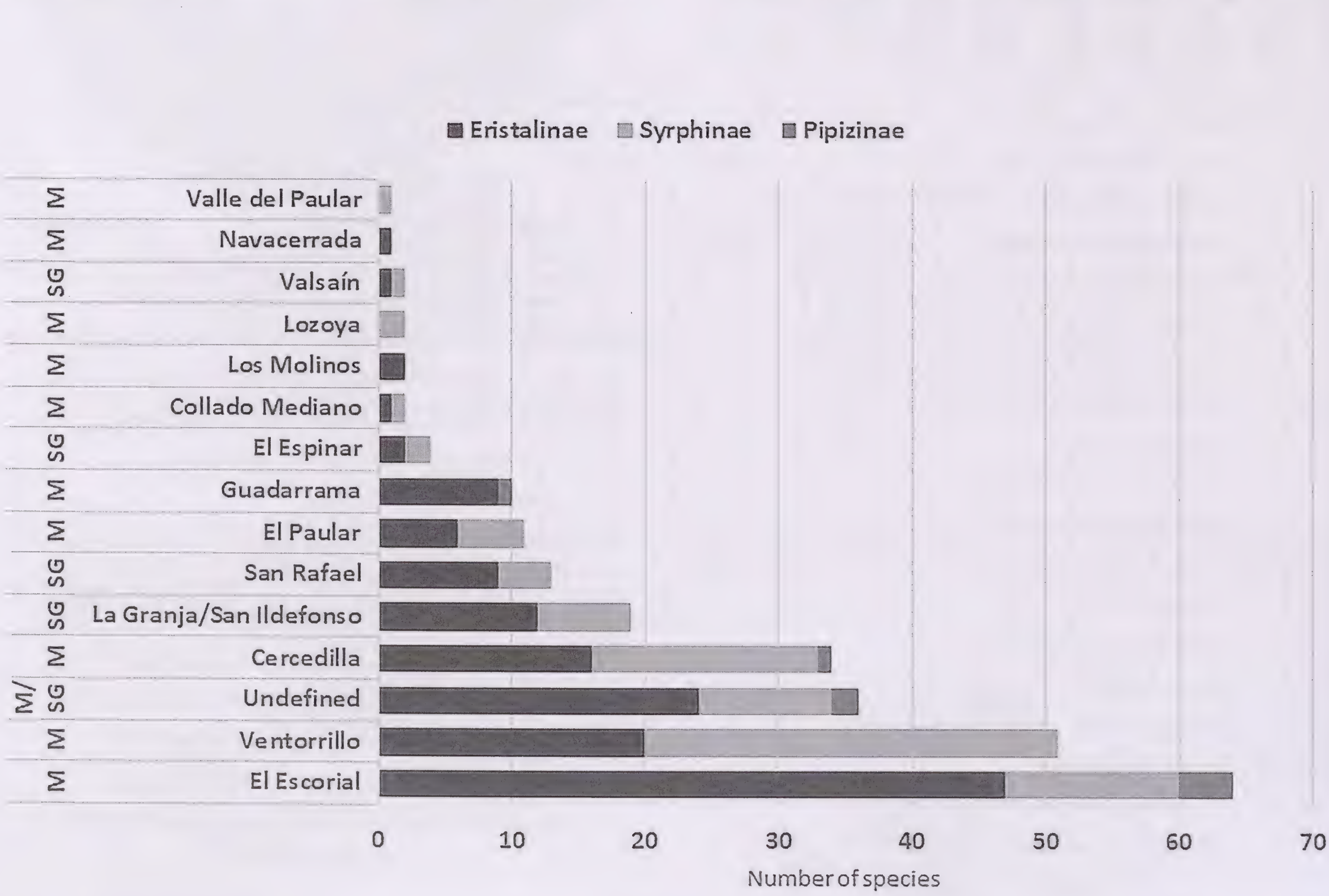


Fig. 5. Hoverfly diversity of Sierra de Guadarrama (species richness). All localities with hoverfly records in the literature are included. The category 'undefined' refers to unspecified localities within Sierra de Guadarrama. M, Madrid province; SG, Segovia province.

useful in understanding how uneven hoverfly knowledge is in Sierra de Guadarrama and to show basic tendencies based on Malaise trap sampling.

In this study, 17 species and two genera are new to Madrid province and the checklist of the Syrphidae from this province consists now of 150 species (Appendix). Madrid is still the third Spanish province in hoverfly species richness, after León (182 spp.) (Ricarte & Marcos-García, 2017) and Salamanca (152 spp.) (Ricarte *et al.*, 2018). In the Malaise trap catch of El Ventorrillo, 34% of species found in the Madrid province are represented. Following the present study, microdontines are still uknown to the province of Madrid.

DISCUSSION

In this study, 17 hoverfly species and two genera were found to be new to Madrid province from a Malaise trap catch originating from El Ventorrillo, Sierra de Guadarrama, dating from 1989-1990. One of the most remarkable aspects brought to light by these results is the

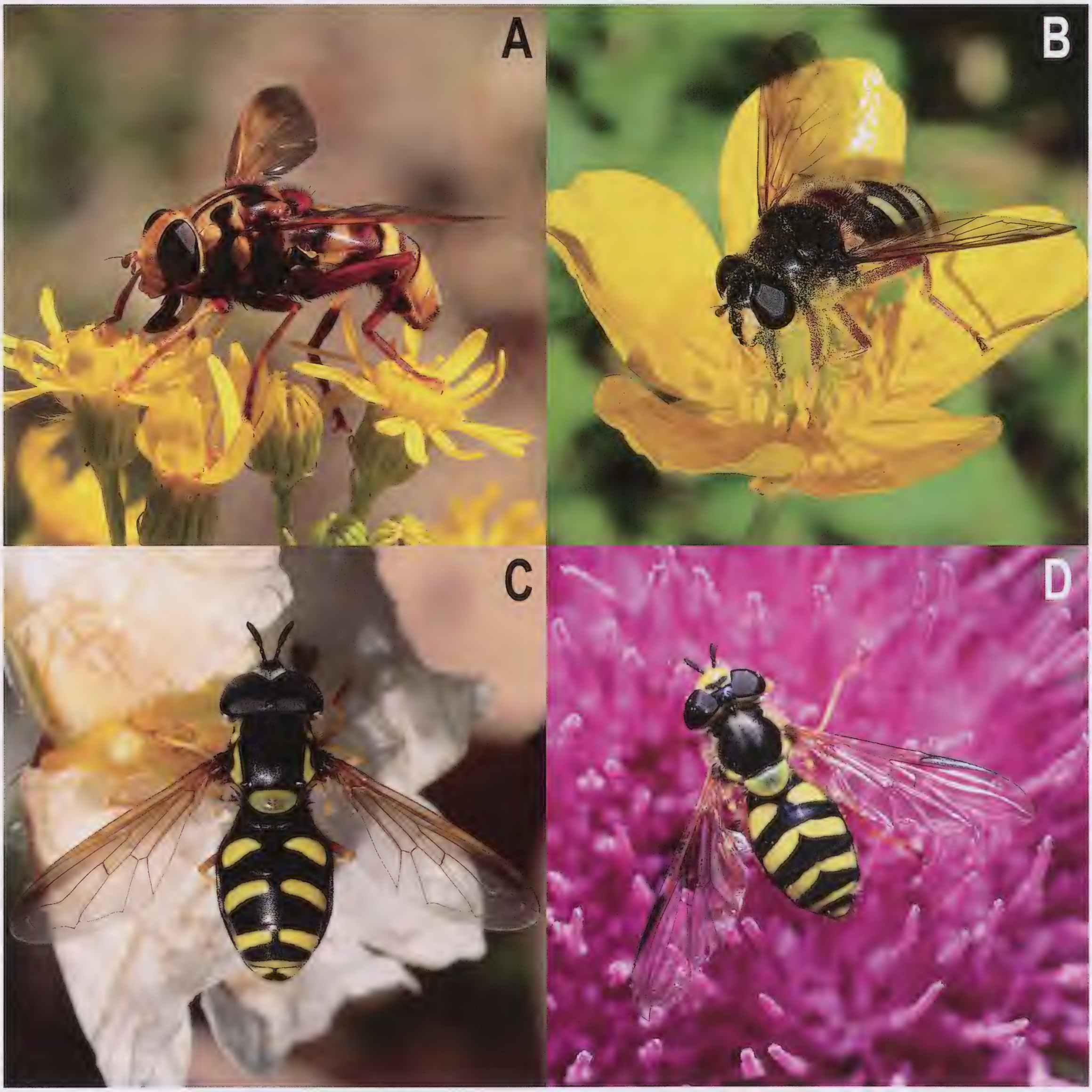


Fig. 6. Hoverfly species from Sierra de Guadarrama. (A) *Milesia crabroniformis*, female, Puerto de Navacerrada. (B) *Sericomyia hispanica*, female, Puerto de Navacerrada. (C) *Chrysotoxum* sp. near *vernale*, male, Puerto de la Morcuera. (D) *Dasysyrphus albostriatus*, female. Photos A, B, D by Piluca Álvarez-Fidalgo, C by Marián Álvarez-Fidalgo.

lack of long term surveys of the hoverfly fauna of Madrid since 1989. Only a few species have been reported from Madrid in scattered publications in the last 30 years (see some examples in Appendix). On the one hand, these results show how important long term surveys are even in a province whose hoverfly diversity is thought to be well known (Ricarte & Marcos-García, 2017). On the other hand, the finding of 21 species new to Sierra de Guadarrama suggests the high potential of this location within the Iberian Peninsula for hoverfly diversity studies, as shown by other insect groups (Lobo & Martín-Piera, 2002; Nieves-Aldrey *et al*., 2003).

The hoverfly community of El Ventorrillo was represented in the Malaise trap catch by 51 species, most of them Mediterranean faunistic elements (Fig. 4), without records of Microdontinae and Pipizinae. Syrphinae were dominant in the samples, with more than half of the species (31 spp.) and individuals of Syrphidae identified (1999 out of 2050). These results were consistent with previous findings. For example, syrphines appear to be less specialised in flower visitation than other subfamilies (Klecka *et al*., 2018) and this fact is likely to facilitate a higher species diversity of syrphines with no regard of the plant community found in a study site. Syrphines are also known to be more diverse in forests than in other habitats (Branquart & Hemptinne, 2000). The Malaise trap used in the present study was placed in a grassland/forest edge, so an influence from the forest community of syrphines was expected in the Malaise trap catch.

Sphaerophoria scripta and *Eupeodes corollae*, both of them syrphines, were the most abundant species in the sample, with 1146 and 351 specimens collected. These two species were not only abundant, but also occurred during a long period throughout the year, 5-6 months (Table 1). Sadeghi & Husseini (2009) also found in Iran that Malaise samples were clearly dominated by these two common species plus *Episyrphus balteatus*. The high ecological success of *S. scripta* and *E. corollae* is, without doubt, mediated by the high spectrum of prey of their zoophagous larvae, found in a wide range of plants, from herbs to trees (Rojo *et al*., 2003). In fact, zoophagous hoverflies dominate our Malaise trap sample from El Ventorrillo (Fig. 3).

Eristalines were more rarely collected than syrphines at El Ventorrillo, both in number of species and individuals. In addition, they had a shorter period of occurrence in the samples, of 1-2 months in most species (Table 1). This lower number of eristalines in the Malaise samples, with genera found in Sierra de Guadarrama poorly represented or even absent (see Appendix) is a consequence of the rarity and behaviour of some species. For example, *Volucella* hoverflies are frequently found flying high (Speight, 2020) and this behaviour reduces the chance for them to get captured with Malaise traps (just one specimen of *Volucella* in this Malaise catch). Saproxylic species such as those of *Spilomyia* are never abundant, their larvae live in tree rot-holes and adults visit flowers in grassy clearings (Speight, 2020). In a one-year long sampling with six Malaise traps in the woodlands of Cabañeros National Park (Ciudad Real) just two specimens of *Spilomyia* were collected (Ricarte, 2008). In general, Burgio & Sommaggio (2002, 2007) and Sommaggio & Burgio (2003) found that Malaise traps are less effective in catching saprophagous hoverflies (all saprophagous species are eristalines) than zoophagous (zoophagous species are syrphines, pipizines, microdontines, and a few *Volucella* species, which are eristalines).

Regarding the absence of Microdontinae and Pipizinae, we dismiss an overlook of these groups when sorting the Malaise catches because the person in charge was able to extract genera that can go unnoticed for someone with insufficient experience due to the small size and/or uniformly dark colouration of these flies: *Cheilosia*, *Eumerus*, *Neoascia*, *Paragus*, *Platycheirus*, and *Syritta*. That said, no *Microdon* species has ever been collected in Madrid and adjacent provinces (Ricarte & Marcos García, 2017). This lack of information on *Microdon* from this part of Spain is most likely to be an artefact of the sampling techniques and collectors. Microdontines are rarely collected and their capture frequency with Malaise traps is low (Reemer, 2012). For example, two *Microdon* species occur in the Cévennes national park, France, but they were not collected in a two-year long study with two Malaise traps within the park (Descaves, 2016). The difficulty to catch microdontines with Malaise traps is likely due to the low mobility and behaviour of *Microdon* adults: some European species disperse just a few meters from their natal ant nests and, in addition, females appear to walk more than fly (Schönrogge *et al*., 2006; Wolton, 2011).

Pipizines is the other subfamily not represented in the Malaise catch of El Ventorrillo. Seven pipizine species are recorded from Madrid, five of them in Sierra de Guadarrama. However, records of all but one species are old (1930 or earlier) (Ricarte & Marcos-García, 2017); *Pipizella lyneborgi* Torp Pedersen, 1971, the exception, was recorded from a female collected in El Escorial in 1973 (Van Steenis & Lucas, 2011). The pipizine genus with the highest number of species recorded in Madrid is *Pipizella* Rondani, 1856 (see Appendix). The larvae of this genus are zoophagous in ant-attended aphids, but the larvae of most *Pipizella* species are unknown (Speight, 2020). Pipizines also appear to be rarely collected in Malaise traps. For example, in Cabañeros (Spain) no pipizine was collected with 10 Malaise traps in five different types of habitats during a year (Ricarte, 2008). In the Cévennes (France) just 1.4% of all collected hoverflies were pipizines (*Pipiza* + *Pipizella*) (Descaves, 2016). The absence of pipizines from the studied samples seem to be in accordance with the results of other Malaise-based surveys in Europe.

In this 1989-1990 Malaise trap sample from El Ventorrillo, 41% of the species known from Sierra de Guadarrama were collected. In the Cévennes national park's sampling

effort mentioned above, one trap/year collected an average of 39% of the species recorded from this national park (Descaves, 2016), which is a very similar proportion as that between El Ventorrillo and Sierra de Guadarrama. In addition, the Malaise traps used both in the Cévennes and El Ventorrillo failed in catching microdontines and had a low success in catching pipizines (none in El Ventorrillo), as explained above. From this and other studies (e.g. Sommaggio & Burgio, 2003; Ricarte, 2008; Descaves, 2016), it is obvious that Malaise traps do not provide a full inventory of species found in an area. However, the hoverflies of a Malaise trap catch represent the community of at least the two major subfamilies (Eristalinae and Syrphinae) and provide the means to compare the largest proportion of the hoverfly diversity of a site through time, as Malaise traps, if set up at the right location, allow a systematic sampling of easy repetition with no regard to the collector skills and experience. Thus, although for a full species inventory of an area different sampling techniques should be used (Ricarte, 2008; Marcos García *et al.*, 2012), Malaise traps provide an adequate experimental design and baseline to compare tendencies in the hoverfly diversity over time. We consider that the species sample presented here could be compared with future samples obtained from El Ventorrillo with a similar sampling design.

With 126 species, Sierra de Guadarrama has 83% of the species recorded from Madrid province, and this becomes the most diverse location of Madrid and adjacent provinces for hoverflies. This high hoverfly diversity is in accordance with the high levels of biodiversity reported for other insect groups in Sierra de Guadarrama (e.g., Lobo & Martín-Piera, 2002; Nieves-Aldrey *et al.*, 2003). However, the proximity of Madrid city has surely had an effect in the knowledge of biodiversity in Sierra de Guadarrama, because many collectors from the city have focused on this location for fieldwork along history; for example, collectors used to sample hoverflies in localities within Sierra de Guadarrama at least since the early twentieth century (Gil-Collado, 1930). Even nowadays, Sierra de Guadarrama is the preferred and most convenient area for city naturalists to monitor biodiversity (Fig. 6). This long history of surveys and monitoring together with the set of data provided here for El Ventorrillo makes Sierra de Guadarrama suitable for planning studies on the effects of Global change on the biodiversity of Syrphidae.

El Ventorrillo is a shelter for species of hoverflies with decreasing populations in Europe or even threatened with extinction. *Callicera macquarti* ('threatened') belongs to the saproxylic guild, with larvae developing in rot holes of mature trees (Ricarte *et al.*, 2009). Thus, forestry practices at El Ventorrillo and surroundings should allow trees to grow in size and develop holes, to promote the breeding of this rare species distributed around the Mediterranean. *Pelecocera caledonica* ('threatened') is present from Scandinavia and European Russia to Spain, where it was known only from Navarra (Speight, 2020). To propose conservation actions for *P. caledonica* would be more difficult than for *C. macquarti* since its larval biology, although suspected to be phytophagous, is completely unknown; further research on the larval biology of *P. caledonica* is required. El Ventorrillo populations of these two species and those of the 'decreasing', *C. rufa*, *C. cisalpinum*, *C. octomaculatum*, and *E. consimilis*, should be monitored to better understand the population size and trend in this part of Europe.

ACKNOWLEDGMENTS

We are grateful to Carmen Rey-del-Castillo for helping with the Malaise trap sampling and sorting. We are also grateful to Diptera expert, Arabia Sánchez-Terrón (MNCN) for having separated the hoverflies from other Diptera. We thank Christian Kehlmaier to send us copies of his papers on Diptera from El Ventorrillo, and Piluca and Marián Álvarez-Fidalgo for allowing us to use their hoverfly photos. We also thank the reviewers for their useful comments to enhance the quality of this paper. English was kindly revised by Dr Martin Hauser (CDFA, USA). We thank Vicerrectorado de Investigación y Transferencia de Conocimiento, University of Alicante to fund Antonio Ricarte's position (UATAL05). This study belongs to the 'Fauna Ibérica' Project PGC2018-095851-A-C65A ('Ministerio de Ciencia, Innovación y Universidades', Spain).

REFERENCES

Allué Andrade J.L. 1987. Memoria del mapa de subregiones fitoclimáticas [pp. 221-223]. *In:* Rivas Martínez S. (ed.), Memoria del mapa de series de vegetación de España (1:400.000). *Ministerio de Agricultura, Pesca y Alimentación (ICONA). Madrid*, 268 pp.

Becker T. 1921. Neue Dipteren meiner Sammlung. *Mitteilungen aus dem Zoologischen Museum in Berlin* 10: 1-93.

Branquart E., Hemptinne J.-L. 2000. Selectivity in the exploitation of floral resources by hoverflies (Diptera: Syrphidae). *Ecography* 23: 732-742.

Burgio G., Sommaggio D. 2002. Diptera Syrphidae caught by Malaise trap in Bologna province and new record of *Neoascia interrupta* in Italy. *Bulletin of Insectology* 55(1-2): 43-47.

Burgio G., Sommaggio D. 2007. Syrphids as landscape bioindicators in Italian agroecosystems. *Agriculture, Ecosystems and Environment* 120: 416-422.

Collin J.E. 1940. Notes on Syrphidae (Diptera). IV. *The Entomologist's monthly magazine* 76: 150-158.

Curtis J. 1837. British entomology. Vol. 14, pls 650-653. Privately published, London.

Czerny L., Strobl P.G. 1909. Spanische Dipteren. III. *Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien* 59: 121-301.

Darling D.C., Packer L. 1988. Effectiveness of Malaise traps in collecting Hymenoptera: The influence of trap design, mesh size, and location. *Canadian Entomologist* 120: 787-790.

Descaves B. 2016. Diagnostic écologique de forêts de la vallée de la Haute Jonte (Lozère) par la méthode "Syrph the Net". *Syrph the Net, the database of European Syrphidae*, *Syrph the Net publications, Dublin,* Vol. 88, 69 pp.

Enderlein G. 1938. Beitrag zur Kenntnis der Syrphiden. *Sitzungsberichte der Gesellschaft Naturforschender Freunde Berlin* 1937: 192-237.

Fabricius J.C. 1775. *Systema entomologiae, sistens insectorum classes, ordines, genera, species, adiectis synonymis, locis, descriptionibus, observationibus*. Kortii, Flensbvrgi et Lipsiae [= Flensburg & Leipzig]. [32] + 832 pp.

Fabricius J.C. 1781. *Species insectorum. Vol. 2,* C. E. Bohnii, Hamburgi et Kilonii [= Hamburg and Kiel], 494 pp.

Fabricius J.C. 1794. *Entomologia systematica emendata et aucta*. C. G. Proft, Hafniae [=Copenhagen], Vol. 4, [6] + 472 + [5] pp.

Fabricius J.C. 1805. *Systema antliatorum secundum ordines, genera, species*. C. Reichard, Brunsvigae [=Brunswick], xiv + 15-372 + [1] + 30 pp.

Fallén C.F. 1816-1817. *Syrphici Sveciae. Berlingianis, Lundae [= Lund],* 1-14 [1816.06.08], 15-22 [1816.06.08], 23-30 [1817.05.10], 31-42 [1817.05.20], 43-54 [1817.05.21], 55-62 [1817.05.22] pp.

Frey R. 1946. Ubersicht der Gattungen der Syrphiden-Unterfamilie Syrphinae (Syrphine + Bacchinae). *Notulae Entomologicae* 25: 152-172.

García-Barros E., Gurrea P., Luciáñez M.J., Martín-Cano J., Munguira M.L., Moreno J.C., Sainz H., Sanz M.J., Simón J.C. 2002. Parsimony analysis of endemicity and its application to animal and plantgeographical distributions in the Ibero-Balearic region (western Mediterranean). *Journal of Biogeography* 29(1): 109-124.

Geer C. de 1776. *Mémoires pour servir* à *l'histoire des insectes. P. Hesselberg, Stockholm*. Vol. 6, viii + 523 pp., 30 pls.

Geoffroy E.L. 1762. Histoire abrégée des insectes... de Paris. Durand, Paris. Vol. 2, 690 pp., pls 11-22.

Gil-Collado J. 1930. Monografia de los Sírfidos de España. *Trabajos del Museo Nacional de Ciencias Naturales (Serie Zoológica)*, 54, 376 pp.

Goeldlin de Tiefenau P. 1976. Revision du genre *Paragus* (Dipt., Syrphidae) de la région paléarctique occidentale. *Bulletin de la Société entomologique suisse* 49: 79-108.

Grković A., Smit J., Radenković S., Vujić A., Van Steenis J. 2019. Two new European long-legged hoverfly species of the *Eumerus binominatus* species subgroup (Diptera, Syrphidae). *ZooKeys* 858: 91-108.

Harris M. 1776-1780. An exposition of English insects... Robson Co., London, 1776. Decad I, pp. 1-40, 2 pls + pls 1-10 [1776.??.??]; Decad II, pp. 41-72, pls 11-20 [1778.??.??]; Decads III, IV, pp. 73-99, 100-138, pls 21-30, 31-40 [after 1779.12.24]; Decad V, pp. 139-166, pls 41-50 + 1 pl. [1780.??.??].

Kehlmaier C. 2004. Faunistic and taxonomic notes of Anisopodidae, Acroceridae, Conopidae and Stratiomyidae (Diptera) collected on the Iberian Peninsula. *Faunistische Abhandlungen* 25: 125-137.

Kehlmaier C. 2005. Taxonomic revision of European Eudorylini (Insecta, Diptera, Pipunculidae). *Verhandlungen des Naturwissenschaftlichen Vereins in Hamburg* 41: 45-353.

Kehlmaier C., Gibbs D.J., Withers P. 2019. New records of big-headed flies (Diptera: Pipunculidae) from the Mediterranean Basin. *Bonn zoological Bulletin* 68(1): 31-60.

Klecka J., Hadrava J., Biella P., Akter A. 2018. Flower visitation by hoverflies (Diptera: Syrphidae) in a temperate plant-pollinator network. *PeerJ* 6: e6025.

Latreille P.A. 1804. Tableau méthodique des insectes [pp. 129-200]. *In:* Latreille P.A. (ed.). Société de Naturalistes et d'Agriculteurs, Nouveau dictionnaire d'histoire naturelle... Tome 24. [Section 3]: *Tableaux méthodiques d'histoire naturelle. Deterville, Paris*, 84 + 4 + 85 + 238 + 18 + 34 pp.

Lepeletier A.L.M., Serville J.G.A. 1828. Various articles on insects. *In:* Latreille P.A., Lepeletier A.L.M, Serville J.G.A, Guérin-Méneville F.E (eds), *Encyclopédie Méthodique, Insectes, Paris*, pp. 345-833.

Linnaeus C. 1758. *Systema naturae*. Ed. 10, Vol. 1. 824 pp. L. Salvii, Holmiae [= Stockholm].

Lobo J.M., Martín-Piera F. 2002. Searching for apredictive model for species richness of Iberian dungbeetle based on spatial and environmental variables. *Conservation Biology* 16(1): 158-173.

Lobo J.M., Castro I., Moreno J.C. 2001. Spatial and environmental determinants of vascular plant species richness distribution in the Iberian Peninsula and Balearic Islands. *Biological Journal of the Linnaean Society* 73: 233-253.

Loew H. 1841. Ueber die Gattung *Chrysotoxum*. *Stettiner Entomologische Zeitung* 2: 136-141, 155-160.

Loew H. 1854. Neue Beiträge zur Kenntniss der Dipteren. *Programm der Königlichen Realschule zu Meseritz* 1854: 1-24.

Loew H. 1862. Ueber einige bei Varna gefangene Dipteren. *Wiener Entomologische Monatsschrift* 6: 161-175.

Macquart P.J.M. 1829. *Insectes diptères du nord de la France. Syrphies*. Lille. «1827» 223 pp., 4 pls.

Macquart P.J.M. 1834. *Histoire naturelle des insectes. Diptères. Tome premier. Roret, Paris*, 578 + 8 pp., 12 pls.

Marcos-García M.A., Louis, M. 2001. Revisión de las especies de sírfidos de la Colección J. Andréu (Diptera, Syrphidae). *Anales de Biología* [1998] 23: 49-62.

Marcos-García M.A., Ricarte A. 2009. Los sírfidos (Diptera: Syrphidae) saproxílicos como indicadores del estado de conservación del Parque Nacional de Cabañeros [pp. 201-213]. *In:* Ramírez L., Asensio B. (eds), Proyectos de investigación en parques nacionales: 2005-2008. *Ministerio del Medio Ambiente, Madrid,* 262 pp.

Marcos-García M.A., Vujić A., Mengual X. 2007. Revision of Iberian species of the genus *Merodon* Meigen, 1803 (Diptera: Syrphidae). *European Journal of Entomology* 104(3): 531-572.

Marcos-García M.A., García-López A., Zumbado M.A., Rotheray G.E. 2012. Sampling methods for assessing syrphid biodiversity (Diptera: Syrphidae) in tropical forests. *Environmental Entomology* 41(6): 1544-1552.

Marshall S.A. 2012. Flies: the natural history and diversity of Diptera. *Firefly Books Ltd, USA and Canada*, 616 pp.

Matsumura S., Adachi J. 1917. Synopsis of the economic Syrphidae of Japan. (Pt III). *The Entomological Magazine, Kyoto* 3: 14-46.

Meigen J.W. 1803. Versuch einer neuen Gattungs-Eintheilung der europaischen zweiflugligen Insekten. *Magistrate Insektenkd.* 2: 259-281.

Meigen J.W. 1822. *Systematische Beschreibung der bekannten europaischen zweiflugeligen Insekten. Dritter Theil. Schulz-Wundermann, Hamm.* x + 416 pp., pls 22-32.

Nedeljković Z., Ačanski J., Vujić A., Obreht D., Djan M., Ståhls G., Radenković S. 2013. Taxonomy of *Chrysotoxum*

festivum Linnaeus, 1758 (Diptera: Syrphidae) – an integrative approach. *Zoological Journal of the Linnean Society* 169: 84-102.

Nedeljković Z., Ačanski J., Djan M., Obreht-Vidaković D., Ricarte A., Vujić A. 2015. An integrated approach to delimiting species borders in the genus *Chrysotoxum* Meigen, 1803 (Diptera: Syrphidae), with description of two new species. *Contributions to Zoology* 84: 285-304.

Nedeljković Z., Ricarte A., Šašić-Zorić Lj., Djan M., Hayat R., Vujić A., Marcos-García M.A. 2020. Integrative taxonomy confirms two new West-Palaearctic species allied with *Chrysotoxum vernale* Loew, 1841 (Diptera: Syrphidae). *Organisms Diversity and Evolution* (in press).

Nieves-Aldrey J.L., Rey Del Castillo C. 1991. Ensayo preliminar sobre la captura de insectos por medio de una trampa Malaise en la sierra de Guadarrama (España) con especial referencia a los himenópteros (Insecta, Hymenoptera). *Ecologia* 5: 383-403.

Nieves-Aldrey J.L., Fontal-Cazalla F., Garrido-Torres A.M., Rey del Castillo C. 2003. Inventario de Hymenoptera (Hexapoda) en el Ventorrillo: un rico enclave de biodiversidad en la sierra de Guadarrama (España central). *Graellsia* 59(2-3): 24-43.

Osten Sacken C.R. 1875. On the North American species of the genus *Syrphus* (in the narrowest sense). *Proceedings of the Boston Society of Natural History* (1875-1876) 18: 135-153.

Osten Sacken C.R. 1877. Western Diptera: Descriptions of new genera and species of Diptera from the region west of the Mississippi and especially from California. *Bulletin of the U.S. Geological Survey* 3: 189-354.

Panzer G.W.F. 1806. *Faunae insectorum germanicae initiae oder Deutschlands Insecten, H. 104, Nurnberg*, 24 pp., 24 pls.

Peris S.V. 1962. Los Sericomyiinae de España con descripción de una nueva especie de *Sericomyia* (Diptera, Syrphidae). *Boletín de la Real Sociedad Española de Historia Natural* 60(1): 55-60.

Poda von Neuhaus N. 1761. *Insecta musei Graecensis, quae in ordines, genera et species juxta Systema Naturae Caroli Linnaei digessit. Widmanstadii, Graecii [=Graz]* 127 + [xii] pp., 2 pls.

Popović D., Ačanski J., Djan M., Obreht D., Vujić A., Radenković S. 2015. Sibling species delimitation and nomenclature of the *Merodon avidus* complex (Diptera: Syrphidae). *European Journal of Entomology* 112(4): 790-809.

Reemer M. 2012. Phylogeny and classification of the Microdontinae (Diptera: Syrphidae) (PhD. thesis). *University of Leiden, Leiden, The Netherlands,* 384 pp.

Reyero J.M. 2002. La Naturaleza de España. *Ministerio de Medio Ambiente, Madrid (España)*, 381 pp.

Ricarte A. 2008. Biodiversidad de sírfidos (Diptera: Syrphidae) y conservación de los hábitats en el Parque Nacional de Cabañeros, España (doctoral thesis). *Universidad de Alicante, Alicante, Spain,* 244 pp (+CD with full list of material examined).

Ricarte A., Marcos-García M.A. 2017. A checklist of the Syrphidae (Diptera) of Spain, Andorra and Gibraltar. *Zootaxa* 4216(5): 401-440.

Ricarte A., Jover T., Marcos-García M. A., Micó E., Brustel H. 2009. Saproxylic beetles (Coleoptera) and hoverflies (Diptera: Syrphidae) from a Mediterranean forest: towards a better understanding of their biology for species conservation. *Journal of Natural History* 43(9): 583-607.

Ricarte A., Nencioni A., Tubić N.K., Grković A., Vujić A., Marcos-García M.A. 2018. The hoverflies of an oak Dehesa from Spain, with a new species and other insights into the taxonomy of the *Eumerus tricolor* group (Diptera: Syrphidae). *Annales Zoologici* 68: 259-280.

Rivas-Martínez S. 1982. Memoria del mapa de las series de vegetación de la provincia de Madrid (1:200.000). *Diputación de Madrid, Servicio Forestal y Medio Ambiente. Madrid,* 48 pp.

Rojo S., Gilbert F., Marcos-García M.A., Nieto J.M., Mier M.P. 2003. A world review of predatory hoverflies (Diptera, Syrphidae: Syrphinae) and their prey. *CIBIO Ediciones, Alicante*, 319 pp.

Rondani C. 1844. *Species Italicae Generis Callicerae ex insectis Dipteris, distinctae et descriptae; Fragmentum octavum ad inserviendum Dipterologiae Italicae. Annales de la Société entomologique de France* (2) 2: 61-68.

Rondani C. 1845. *Species Italicae generis Chrysotoxi insectis Dipteris, observatae et distinctae. Fragmentum decimum ad inserviendum dipterologiae Italicae. Annales de la Société entomologique de France* (2) 3: 193-203.

Rondani C. 1857. *Dipterologiae italicae prodromus.* Vol: II. *Species italicae ordinis dipterorum in genera characteribus definita, ordinatim collectae, methodo analitica distinctae, et novis vel minus cognitis descriptis. Pars prima. Oestridae: Syrpfhidae: Conopidae. A. Stocchi, Parmae* [= Parma], 264 pp.

Rondani C. 1868. *Diptera Italica non vel minus cognita descripta vel annotata observationibus nonnullis additis.* Fasc. III. *Atti della Società italiana di scienze naturali e del Museo civico di storia naturale di Milano* 11: 21-54.

Rotheray G.E. 1994. Colour guide to hoverfly larvae (Diptera, Syrphidae) in Britain and Europe. *Dipterists Digest* 9: 1-156.

Rotheray G.E., Gilbert F. 2011. The natural history of hoverflies. *Forrest Text, Cardigan, UK*, 333 pp.

Sadeghi Namaghi H., Husseini M. 2009. The effects of collection methods on species diversity of family Syrphidae (Diptera) in Neyshabur, Iran. *Journal of Agricultural Science and Technology* 11(5): 521-526.

Schiner I. R. 1860. Vorlaufiger Commentar zum dipterologischen Theile der ‚Fauna Austriaca', mit einer naheren Begrundung der in derselben aufgenommenen neuen Dipteren-Gattungen. II. *Wiener Entomologische Monatschrift* 4: 208-216.

Schönrogge K., Gardner M.G., Elmes G.W., Napper E.K.V., Simcox D.J., Wardlaw J.C., Breen J., Barr B., Knapp J.J., Pickett J.A., Thomas, J.A. 2006. Host propagation permits extreme local adaptation in a social parasite of ants. *Ecology letters* 9: 1032-1040.

Schummel T.E. 1842. Verzeichniss und Beschreibung der bis jetzt in Schlesien gefangenen Zweiflugler der Syrphen Familie. *Uebersicht der Arbeiten und Veranderungen der Schlesischen Gesellschaft fiir Vaterlandische Kultur*: 15-22.

Séguy E. 1961. *Diptères syrphides d'Europe Occidentale. Mémoires du Muséum national d'Histoire naturelle* Série (A) 23, 248 pp.

Šimić S., Vujić A. 1996. A new species of the genus *Eumerus* Meigen, 1822 (Diptera: Syrphidae. *Acta Entomologica serbica* 1: 1-14.

Sommaggio D., Burgio G. 2003. Role of Diptera Syrphidae as

landscape indicators: analysis of some case studies in Northern Italy. *Landscape management for Functional Biodiversity* 26(4): 145-150.

Speight M.C.D. 1989. Saproxylic invertebrates and their conservation. *Council of Europe*, 1st edition, 81 pp.

Speight M.C.D. 2020. Species accounts of European Syrphidae, *2020. Syrph the Net, the database of European Syrphidae (Diptera). Syrph the Net publications, Dublin* 104: 1-314.

Speight M.C.D., Castella E. 2005. Diagnostic de pelouses et landes subalpines, à l'aide des diptères Syrphidae. *Rapport au conservatoire des réserves naturelles de Haute-Savoie*, 57 pp.

Speight M.C.D., Sarthou J.-P. 2017. StN keys for the identification of the European species of various genera of Syrphidae 2017/Clés StN pour la détermination des espèces européennes de plusieurs genres de Syrphidae 2017. *Syrph the Net, the database of European Syrphidae (Diptera), Syrph the Net publications, Dublin* Vol. 99, 139 pp.

Speight M.C.D., Castella E., Sarthou J.-P. 2016. StN 2016. *In:* Syrph the Net on CD, Issue 11, Speight M.C.D., Castella E., Sarthou J.-P., Vanappelghem C. (eds). *Syrph the Net Publications, Dublin.*

Torp Pedersen E. 1971. Some Syrphidae from Spain, with descriptions of two new species (Insecta, Diptera). *Steenstrupia* 1(21): 229-245.

Townes A. 1972. A light-weigth Malaise trap. *Entomological News* 83: 239-247.

Van Steenis J., Lucas J.A.W. 2011. Revision of the West-Palaearctic species of *Pipizella* Rondani, 1856 (Diptera, Syrphidae). *Dipterists Digest* 18: 127-180.

Van Steenis J., Hauser M., Van Zuijen M.P. 2017. Review of the *Eumerus barbarus* species group (Diptera: Syrphidae) from the western Mediterranean basin. *Bonn zoological Bulletin* 66: 145-165.

Van Steenis J., Van Zuijen M.P., Ricarte A., Marcos-García M.A., Doczkal D., Ssymank A., Mengual X. 2020. First records of *Chrysotoxum volaticum* Séguy, 1961 from Europe and *Platycheirus marokkanus* Kassebeer, 1998 from Spain (Diptera: Syrphidae) together with additional records of Spanish *Chrysotoxum* Meigen, 1803. *Bonn zoological Bulletin* 69(1): 141-155.

Van Veen M. 2004. Hoverflies of Northwest Europe: identification keys to the Syrphidae. *KNNV Publishing, Utrecht, Netherlands,* 256 pp.

Verrall G. H. 1873. Additions and correction to the list of British Syrphidae. *Entomologist's Monthly Magazine* 9: 251-256.

Verrall G.H. 1901. Platypezidae, Pipunculidae and Syrphidae of Great Britain. *British flies. Gurney & Jackson, London* Vol. 8, [i] + 691 pp.

Violovitsh N. A. 1974. A review of the Palaearctic species of the genus *Chrysotoxum* Mg. (Diptera, Syrphidae). *Entomologocskoc obozrenie (Entomological Review)* 53: 196-217.

Vujić A., Šimić S. 1999. Genus *Eumerus* Meigen 1822 (Diptera: Syrphidae) in area of former Jugoslavia. *Glasnik Prirodnjackog Muzeja u Beogradu*, B 49-50: 173-190.

Williston S.W. 1887. Synopsis of the North American Syrphidae. *Bulletin of the American Museum of Natural History* (1886) 31, xxx + 335 pp, 12 pls.

Wolton R. 2011. Observations on ecology and behaviour of *Microdon myrmicae* Schönrogge et al. (Diptera, Syrphidae), with a description of egg and early instar morphology. *Dipterists Digest* 18: 55-67.

Zetterstedt J.W. 1838. *Dipterologis Scandinaviae.* Sect. 3: Diptera, pp. 477-868. *Insecta Lapponica, Lipsiae [= Leipzig],* vi + 1, 140 pp.

Zetterstedt J.W. 1842-1860. *Diptera Scandinaviae, Officina Lundbergiana, Lundae [=Lund.],* Vol. 1, [before 1842.09.06]; vol. 2, pp. 441-894 [1843.05.02]; vol. 3, pp. 895-1012 [1844.03.20], 1013-1280 [1845.04.09]; vol. 4, pp. 1281-1738 [1845.06.11]; vol. 5, pp. 1739-2162 [1846.09.03]; vol. 6, pp. 2163-2580 [1847.06.09]; vol. 7, pp. 2581-2934 [1848.09.13]; vol. 8, pp. 2935-3366 [1849.09.12]; vol. 9, pp. 3367-3710 [1850.??.??]; vol. 10, pp. 3711-4090 [1851.??.??]; vol. 11, pp. 4091-4545 [1852.03.10]; vol. 12, pp. xx + 4547-4942 [1855.07.??]; vol. 13, pp. xvi+ 4943-6190 [1859.09.01 preface]; vol. 14, pp. iv + 6191-6609 [1860.12.12], pp. iii-xvi+440.

Appendix

Checklist of the Syrphidae from Sierra de Guadarrama, plus all other species (*) recorded in Madrid province.
All mentioned localities belong to Sierra de Guadarrama, Madrid, except for El Espinar, La Granja/San Ildefonso, San Rafael, and Valsaín, that belong to Sierra de Guadarrama, Segovia (Fig. 1). Hoverfly species from El Ventorrillo (in bold) are new to Sierra de Guadarrama when all locality cells are blank (—). 'Sierra de Guadarrama (gen.)' is used when the published locality in a bibliographic record is just 'Sierra de Guadarrama'. Reference legend: GC1930, Gil-Collado (1930); P1962, Peris (1962); MG&L2001, Marcos-García & Louis (2001); MG*etal*2007, Marcos-García *et al*. (2007); VS&L2011, Van Steenis & Lucas (2011). GC1930 always refers to the genus *Cheilosia* with the spelling '*Chilosia*'.
For a checklist of the Syrphidae from Madrid province exclusively, the following Segovian species should be excluded from this table: *Callicera spinolae*, *Cheilosia flavipes*, *Epsitrophe nitidicollis*, *Eristalis pertinax*, *Merodon equestris*, *Volucella pellucens*, and *Xanthogramma citrofasciatum*.

	GC1930	P1962 / MG&L2001 / MGetal2007 / VS&L2011
ERISTALINAE		
*Brachypalpoides lentus**		
Brachypalpus laphriformis	—	— / — / — / —
Callicera macquarti	—	— / — / — / —
Callicera rufa	—	— / — / — / —

	GC1930	P1962 / MG&L2001 / MGetal2007 / VS&L2011
Callicera spinolae	La Granja	— / — / — / —
Ceriana vespiformis	Los Molinos, El Escorial (as *Cerioides vespiformis*)	— / — / — / —
Ceriana conopsoides	El Escorial (as *Cerioides conopoides*)	— / — / — / —
Cheilosia aerea	El Escorial (as *Chilosia zetterstedti* and *Chilosia correcta*)	— / — / — / —
*Cheilosia barbata**		
Cheilosia flavipes	San Rafael	— / — / — / —
Cheilosia gigantea	San Rafael	— / — / — / —
*Cheilosia impressa**		
Cheilosia laticornis	El Escorial, Sierra de Guadarrama (gen.) (as *Chilosia latifacies*)	— / Sierra de Guadarrama (gen.) / — / —
*Cheilosia latifrons**		
Cheilosia mutabilis	El Escorial (as *Chilosia ruralis*)	— / — / — / —
Cheilosia proxima	—	— / — / — / —
*Cheilosia soror**		
Cheilosia variabilis	El Escorial	— / — / — / —
Cheilosia vernalis	Cercedilla, Sierra de Guadarrama (gen.)	— / — / — / —
Chrysogaster basalis	Cercedilla, El Escorial	— / — / — / —
Chrysogaster coemiteriorum	Cercedilla (as *C. chalybeata* var. *coerulea*), El Escorial, Sierra de Guadarrama (as *C. chalybeata*)	— / — / — / —
*Chrysogaster virescens**		
Criorrhina asilica	El Escorial	— / — / — / —
*Criorhina ranunculi**		
Eristalinus aeneus	El Escorial, Guadarrama (as *Eristalis aeneus*)	— / — / — / —
Eristalinus sepulchralis	Guadarrama (as *Eristalis taeniops*)	— / — / — / —
Eristalinus taeniops	Sierra de Guadarrama (gen.) (as *Eristalis sepulchralis*)	— / — / — / —
Eristalis arbustorum	Sierra de Guadarrama (gen.)	— / El Escorial, Sierra de Guadarrama (gen.) / — / —
Eristalis horticola	Cercedilla, El Escorial, San Rafael	— / — / — / —
Eristalis nemorum	Sierra de Guadarrama (gen.) (as var. *sylvarum*)	— / — / — / —
Eristalis pertinax	La Granja	— / — / — / —
Eristalis similis	Cercedilla, El Escorial, Navacerrada, San Rafael, Sierra de Guadarrama (gen.) (as *E. pratorum*)	— / — / — / —
Eristalis tenax	Sierra de Guadarrama (gen.)	— / El Escorial, Sierra de Guadarrama (gen.) / — / —
*Eumerus amoenus**		
Eumerus barbarus	El Escorial	— / — / — / —
Eumerus caballeroi	El Escorial	— / — / — / —
Eumerus consimilis	—	— / — / — / —
*Eumerus grallator**		
Eumerus nudus	El Escorial	— / — / — / —
Eumerus pauper	El Espinar, El Sierra de Guadarrama (gen.)	— / — / — / —
Eumerus pulchellus	El Escorial	— / — / — / —
*Eumerus ruficornis**		
Eumerus sabulonum	El Escorial, San Rafael, Sierra de Guadarrama (gen.)	— / — / — / —
Eumerus strigatus	El Escorial, El Espinar	— / — / — / —
Eumerus sulcitibius	—	— / — / — / —

	GC1930	P1962 / MG&L2001 / MGetal2007 / VS&L2011
Eumerus tarsalis	El Escorial	— / — / — / —
Ferdinandea cuprea	El Escorial, El Paular, La Granja	— / — / — / —
Helophilus trivittatus	El Escorial, Guadarrama	— / — / — / —
Lejogaster metallina	San Rafael, Sierra de Guadarrama (gen.) (as *Chrysogaster metallina*)	— / — / — / —
Mallota dusmeti	El Escorial	— / — / — / —
*Mallota fuciformis**		
Melanogaster aerosa	Cercedilla, El Escorial (as *Chrysogaster macquarti*)	— / — / — / —
Merodon aeneus	Cercedilla, La Granja, San Rafael (as var. *crassitarsatus*)	— / Sierra de Guadarrama (gen.) / — / —
Merodon avidus	Cercedilla, El Escorial, El Paular (as *M. spinipes* var. *serrulatus*, var. *obscuritarsis* and var. *avidus*)	— / El Escorial, Sierra de Guadarrama (gen.) / — / —
Merodon chalybeus	El Escorial (as *M. spinipes* var. *obscuritarsis*)	
Merodon clavipes	El Escorial, Guadarrama, El Paular (also as *M. clavipes* var. *senilis*)	— / Sierra de Guadarrama (gen.) / — / —
Merodon escorialensis	El Escorial, Sierra de Guadarrama (gen.) (as *M. geniculatus* var. *escorialensis*)	— / — / El Escorial / —
Merodon equestris	San Ildefonso (as *M. equestris* var. *narcissi*)	— / — / — / —
*Merodon flavus**		
Merodon funestus	El Escorial	— / — / — / —
Merodon geniculatus	El Escorial, Sierra de Guadarrama (gen.)	— / — / — / —
Merodon ibericus	Cercedilla, El Escorial (as *M. spinipes* var. *bicolor*)	— / — / — / —
Merodon italicus	El Escorial (as *M. affinis*)	— / — / — / —
*Merodon nigritarsis**		
*Merodon obscuritarsis**		
Merodon parietum	—	— / Sierra de Guadarrama (gen.) / — / —
Merodon unguicornis	Sierra de Guadarrama (gen.) (also as *M. bolivari*)	— / Sierra de Guadarrama (gen.) (as *M. bolivari*) / Cercedilla / —
Merodon unicolor	Cercedilla, El Escorial, El Paular, Sierra de Guadarrama (gen.) (as *M. aeneus* var. *unicolor*)	— / — / — / —
Milesia crabroniformis	El Escorial, La Granja	— / — / — / —
Milesia semiluctifera	Cercedilla, El Escorial	— / — / — / —
Myathropa florea	El Escorial, El Paular, Guadarrama, La Granja/San Ildefonso (also as *Myiatropa florea* var. *nigrotarsata*)	— / — / — / —
*Myolepta difformis**		
Myolepta dubia	Sierra de Guadarrama (gen.) (as *Myiolepta luteola*)	— / — / — / —
*Neoascia meticulosa**		
Neoascia podagrica	—	— / — / — / —
*Neoascia tenur**		
Orthonevra frontalis	Sierra de Guadarrama (gen.) (as *Chrysogaster frontalis*)	— / — / — / —
*Orthonevra nobilis**		
*Parhelophilus versicolor**		
Pelecocera caledonica	—	— / — / — / —
Pelecocera lusitanica	El Escorial (as *Chamaesyrphus lusitanicus*)	— / — / — / —

	GC1930	P1962 / MG&L2001 / MGetal2007 / VS&L2011
*Platynochaetus setosus**		
*Rhingia rostrata**		
Riponnensia longicornis	El Escorial (as *Chrysogaster longicornis*)	— / — / — / —
Riponnensia splendens	El Escorial, Sierra de Guadarrama (gen.) (as *Chrysogaster splendens*)	— / — / — / —
Sericomyia hispanica	Cercedilla, La Granja (as *S. lappona*)	Cercedilla, La Granja / — / — / —
Sericomyia lappona	El Escorial	— / — / — / —
Spilomyia digitata	El Escorial, Guadarrama	— / Sierra de Guadarrama (gen.) / — / —
Spilomyia saltuum	El Escorial, Los Molinos	
Syritta pipiens	—	— / — / — / —
Volucella bombylans	El Escorial, Guadarrama, San Rafael (also as *V. bombylans* var. *plumata*)	— / — / — / —
Volucella elegans	Cercedilla, Collado Mediano, El Escorial, Guadarrama, La Granja, San Rafael	— / — / — / —
Volucella inanis	El Escorial, Guadarrama	— / — / — / —
Volucella pellucens	La Granja	— / — / — / —
Volucella zonaria	Sierra de Guadarrama (gen.)	— / — / — / —
Xylota segnis	El Escorial, La Granja	— / — / — / —
Xylota sylvarum	Cercedilla, El Paular, La Granja, Valsaín	— / — / — / —
PIPIZINAE		
Claussenia hispanica	El Escorial (as *Pipizella heringii* var. *hispanica*)	— / — / — / —
*Pipiza festiva**		
Pipizella annulata	El Escorial (as *P. virens* var. *annulata*)	— / — / — / —
Pipizella lyneborgi	—	— / — / — / El Escorial
Pipizella maculipennis	Sierra de Guadarrama (gen.)	— / — / — / —
*Pipizella viduata**		
Pipizella virens	Cercedilla, El Escorial, Guadarrama, Sierra de Guadarrama (gen.)	— / — / — / —
SYRPHINAE		
Chrysotoxum bicinctum	Cercedilla	— / — / — / —
Chrysotoxum cisalpinum	—	— / — / — / —
Chrysotoxum festivum	Cercedilla, Lozoya, Sierra de Guadarrama (gen.)	— / El Escorial, Sierra de Guadarrama (gen.) (as *C. arcuatum*) / — / —
Chrysotoxum gracile	Lozoya (as *C. festivum* var. *gracile*)	— / — / — / —
Chrysotoxum intermedium	Cercedilla, El Escorial, La Granja	— / — / — / —
Chrysotoxum latifasciatum	Cercedilla, El Escorial, El Paular, La Granja, Sierra de Guadarrama (gen.), Valsaín	— / Sierra de Guadarrama (gen.) / — / —
Chrysotoxum octomaculatum	—	— / El Escorial (as *C. latifasciatum*) / — / —
Chrysotoxum* sp. *near vernale	—	— / — / — / —
Chrysotoxum vernale	El Escorial	— / — / — / —
Chrysotoxum volaticum	El Escorial, San Ildefonso	— / — / — / —
Dasysyrphus albostriatus	—	— / — / — / —
Dasysyrphus pauxillus	—	— / — / — / —
Dasysyrphus tricinctus	—	— / — / — / —
Didea intermedia	—	— / — / — / —
Doros profuges	Cercedilla (as *Doros conopeus*)	— / — / — / —
*Epistrophe eligans**		
Epistrophe nitidicollis	La Granja	— / — / — / —

	GC1930	P1962 / MG&L2001 / MGetal2007 / VS&L2011
Episyrphus balteatus	Sierra de Guadarrama (gen.)	— / — / — / —
Eupeodes corollae	El Escorial, San Rafael (as *Syrphus luniger*)	— / — / — / —
Eupeodes latifasciatus	—	— / — / — / —
*Eupeodes lucasi**		
Eupeodes luniger	Cercedilla, El Escorial (as *Syrphus corollae* var. *fulvifrons* and var. *nigrofemoratus*)	— / — / — / —
Melangyna triangulifera	El Escorial (as *Syrphus triangulifer*)	— / — / — / —
Melanostoma mellinum	Cercedilla, El Escorial, El Paular	— / — / — / —
Melanostoma scalare	Cercedilla, El Escorial	— / — / — / —
Meliscaeva auricollis	Cercedilla	— / — / — / —
Paragus albifrons	Cercedilla	— / — / — / —
Paragus bicolor	Cercedilla, Collado Mediano, El Escorial, El Espinar, San Rafael, Sierra de Guadarrama (gen.) (also as *P. bicolor* var. *testaceus* and *taeniatus*)	— / — / — / —
*Paragus finitimus**		
Paragus haemorrhous	El Escorial, Sierra de Guadarrama (gen.) (as *P. tibialis* var. *haemorrhous*)	— / — / — / —
Paragus pecchiolii	—	— / — / — / —
Paragus quadrifasciatus	Sierra de Guadarrama (gen.)	— / — / — / —
Paragus strigatus	Cercedilla, El Espinar	— / — / — / —
Paragus tibialis	Sierra de Guadarrama (gen.) (as *P. tibialis* var. *obscurus* and var. *trianguliferus*)	— / — / — / —
*Paragus vandergooti**		
Parasyrphus punctulatus	—	— / — / — / —
Platycheirus albimanus	Cercedilla, El Escorial	— / — / — / —
Platycheirus scutatus	—	— / — / — / —
Scaeva albomaculata	Cercedilla, El Escorial, El Paular (as *Lasyophticus albomaculatus*)	— / — / — / —
Scaeva mecogramma	Cercedilla (as *Syrphus posticatus*)	— / — / — / —
Scaeva pyrastri	El Escorial, El Paular, La Granja, Sierra de Guadarrama (gen.), Valle del Paular (as *Lasyophticus pyrastri*)	— / — / — / —
Scaeva selenitica	Cercedilla, El Escorial, El Paular, San Ildefonso (as *Lasyophticus seleniticus*)	— / — / — / —
*Sphaerophoria interrupta**		
*Sphaerophoria rueppellii**		
Sphaerophoria scripta	Sierra de Guadarrama (gen.)	— / — / — / —
Syrphus ribesii	Cercedilla, El Escorial, La Granja	— / — / — / —
Syrphus torvus	—	— / — / — / —
Syrphus vitripennis	San Rafael (as *S. ribesii* var. *vitripennis*)	— / Sierra de Guadarrama (gen.) / — / —
Xanthandrus comtus	—	— / — / — / —
Xanthogramma citrofasciatum	San Rafael	— / — / — / —
*Xanthogramma marginale**		
Xanthogramma dives	—	— / — / — / —
Xanthogramma pedissequum	El Escorial (as *X. ornatum*)	— / — / — / —

Revue suisse de Zoologie (September 2020) 127(2): 413-422 ISSN 0035-418

Range extension and extended diagnosis of *Lycodon pictus*: First country record from China

Helen Yvonne Janssen[1,2], Ren Jin-Long[3], Li Jia-Tang[3], Wang Zeng[3], Tao Thien Nguyen[4], Truong Quang Nguyen[5,6], Quynh Thi Thuy Bui[7], Hanh Thi Ngo[7,8], Minh Duc Le[8,9,10] & Thomas Ziegler[1,2,*]

[1] *Cologne Zoological Garden, Riehler Strasse 173, D-50735 Cologne, Germany*
[2] *Institute of Zoology, University of Cologne, Zülpicher Strasse 47b, D-50674 Cologne, Germany*
[3] *Chengdu Institute of Biology, Chinese Academy of Sciences, No.9 Section 4, Renmin Nan Road, Chengdu, Sichuan, P.R. China, 610041*
[4] *Vietnam National Museum of Nature, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet Road, Hanoi, Vietnam*
[5] *Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam*
[6] *Graduate University of Science and Technology, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam*
[7] *Faculty of Biology, University of Science, Vietnam National University, Hanoi, 334 Nguyen Trai Road, Hanoi, Vietnam*
[8] *Central Institute for Natural Resources and Environmental Studies, Vietnam National University, Hanoi, 19 Le Thanh Tong, Hanoi, Vietnam*
[9] *Faculty of Environmental Sciences, University of Science, Vietnam National University, Hanoi, 334 Nguyen Trai Road, Hanoi, Vietnam*
[10] *Department of Herpetology, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024, USA*
* *Corresponding author: ziegler@koelnerzoo.de*

Abstract: The Painted Wolf Snake, *Lycodon pictus*, was recently described based on the type series from Trung Khanh and Ha Lang districts in Cao Bang Province, northern Vietnam. Herein, we report new findings and a range extension of the recently described species. One individual was collected close by the type locality, in Ha Lang District, Cao Bang Province, Vietnam and another one in Nonggang National Nature Reserve, Longzhou County, Guangxi Zhuang Autonomous Region, China, approximately 60 km apart from the type locality. Both specimens generally accorded with the morphological diagnosis of *L. pictus* provided in the original description. Molecular analyses supported the morphological findings: the newly collected specimens were approximately 0.3-0.9% (cyt *b*) genetically divergent from those of the type series. Molecular analyses also revealed that the holotype of *L. pictus*, for which no sequences were available so far, showed, based on the results of a formalin protocol, about 0.9-1.3% differentiation from the remaining type series, 0.5% from the new record from Cao Bang and 0.9% from the new record from China. Based on the morphological and molecular findings, we herein present the first country record of *L. pictus* from China, with a detailed morphological description of the specimen from Nonggang National Nature Reserve and slightly extend the original diagnosis of the species.

Keywords: New record, *Lycodon pictus*, China, karst forest, morphology, phylogeny, taxonomy.

INTRODUCTION

The genus *Lycodon* Boie, 1827 is one of the most diverse genera of colubrid snakes, with 64 currently recognized species (Uetz *et al.,* 2020; Wang *et al.,* 2020b). Recent phylogenetic studies showed that the genera *Dinodon*, *Dryocalamus* and *Lepturophis* are nested within *Lycodon* and suggested the taxa to be placed into the genus *Lycodon* (Guo *et al.*, 2013; Siler *et al.*, 2013; Figueroa *et al.*, 2016). The members of *Lycodon* have a broad distribution from eastern Iran to southern China and Japan, southward to the Philippines as well as to the Indo-Australian Archipelago (Lanza, 1999; Siler *et al.*,

Manuscript accepted 26.08.2020
DOI: 10.35929/RSZ.0030

2013; Neang *et al.*, 2014). From Vietnam, sixteen species of *Lycodon* have been reported to date, comprising *L. capucinus* (Boie, 1827), *L. cardamomensis* (Daltry & Wüster, 2002), *L. davisonii* (Blanford, 1878), *L. fasciatus* (Anderson, 1879), *L. flavozonatus* (Pope, 1928), *L. futsingensis* (Pope, 1928), *L. laoensis* Günther, 1864, *L. meridionalis* (Bourret, 1935), *L. namdongensis* Luu, Ziegler, Ha, Le & Hoang, 2019, *L. paucifasciatus* Rendahl in Smith, 1943, *L. pictus* Janssen, Pham, Ngo, Le, Nguyen & Ziegler, 2019, *L. rosozonatus* (Hu & Zhao, 1972 [1975]), *L. rufozonatus* Cantor, 1842, *L. ruhstrati abditus* Vogel, David, Pauwels, Sumontha, Norval, Hendrix, Vu & Ziegler, 2009, *L. septentrionalis* (Günther, 1875) and *L. subcinctus* Boie, 1827 (Uetz *et al.*, 2020). The last description from Vietnam was that of *Lycodon pictus* based on a type series collected from Cao Bang Province, northern Vietnam. Herein, we report new findings of the species, supported by morphological and molecular analyses, resulting in an extended diagnosis and range extension of *L. pictus*.

MATERIAL AND METHODS

Sampling: Field surveys in Vietnam were conducted in Duc Quang Commune, Ha Lang District, Cao Bang Province (22.42'.48"N; 106.39'.55" E, 510 m a.s.l.) on 16 May 2019 by Tao Thien Nguyen, and in China in Nonggang National Nature Reserve, Longzhou County, Guangxi Zhuang Autonomous Region (106°57'18.77" E, 22°28'3.92" N, 233 m a.s.l.) on 8 July 2019 by Jin-Long Ren and Fan-Xing Zeng. The collected specimens were photographed alive, euthanised with ethyl-acetate, fixed in approximately 85% ethanol for 10 hours, and subsequently transferred to 70% ethanol for permanent storage. Liver tissue samples were preserved separately in 95% ethanol. The specimens are deposited in the collections of the Vietnam National Museum of Nature, Vietnam Academy of Science and Technology (VNMN), Hanoi, Vietnam and of Herpetological Museum, Chengdu Institute of Biology, Chinese Academy of Sciences (CIB), Chengdu, China. The holotype, deposited in the Institute of Ecology and Biological Resources, Hanoi, Vietnam, (IEBR 4166) was also included in the molecular analysis.

Morphological analysis: Identification of sex was performed by dissection (inspection of gonads and presence of hemipenes). Maxillary teeth were counted by dissecting the right maxilla for teeth / sockets. Scalation and maxillary teeth number were examined with a binocular dissecting microscope. Measurements were taken following Ziegler *et al.* (2018) with a measuring tape to the nearest 1 mm.

Abbreviations of morphological characters are as follows: SVL - Snout-vent length (from tip of snout to vent); TaL - tail length; TaL/TL - ratio of tail length / total length; TL - total length; DSR - dorsal scale rows number at one head length posterior to the head – number of dorsal scale rows at midbody – number of dorsal scale rows at one head length anterior to the vent; SL - supralabials (counted on upper lips); SL/orbit - number of supralabials entering orbit; IL - infralabials (counted on lower lips); Lor - loreals; Lor/eye - loreal scale touching the eye (yes or no); PreOc - preoculars; PostOc - postoculars; Atem - number of anterior temporals; Ptem - number of posterior temporals; BodySc - scalation of the body (keeled or smooth); PreVen - number of preventral scales; Ven - number of ventral scales; SubC - number of subcaudal scales; PreC - precloacal (or cloacal) plate (single or divided); Teeth max - number of maxillary teeth / alveoli. Scale counts were taken following Vogel *et al.* (2009). Ventral scales (Ven) were counted according to Dowling (1951). Bilateral scale counts were given as left / right.

Molecular analysis: A tissue sample was collected from the holotype of *Lycodon pictus* (IEBR 4166) then extracted following formalin protocol developed by Friedman & Desalle (2008) using GTE and

Table 1. Primers used in this study

Primer	Sequence	Reference
L14910	5' – GACCTGTGATMTGAAAACCAYCGTTGT –3'	Burbrink *et al.* (2000)
H16064	5' – CTTTGGTTTACAAGAACAATGCTTTA –3'	Burbrink *et al.* (2000)
Ly_R1	5' – GATGAAAAAGCAAGGTTGATGTT – 3'	This study
Ly_F1	5' – CTACAAACCGTAACCGGATTCTT – 3'	This study
Ly_R2	5' – GGATAAATAGTAGGGTGGTTCCTGAT – 3'	This study
Ly_F2	5' – GGAACCACCCTACTATTTATCCTCAT – 3'	This study
Ly_R3	5' – GGATGAAGTGTAAGGCAAAGAAT – 3'	This study
Ly_F3	5' – GGTTTCTCAATTAATGACCCAA – 3'	This study
Ly_R4	5' – CATTGAATATGTTTGGGGTAAATGAT – 3'	This study
Ly_F4	5' – CACCCTAATAATAACTATTATATT – 3'	This study
Ly_R5	5' – GTTATAGATCGTATGTGGGATGTGTGA – 3'	This study

Puregene Tissue Kit (Qiagen, Germany) following the manufacturer's instructions to allow the efficient recovery of even small amounts of residual undegraded DNA. We designed nine new internal cytochrome *b* primers to optimize the amplification of the degraded DNA sample (Table 1). The sample was cut into small pieces using a sterile razor blade and placed in 1.5 ml centrifuge tube then removed formalin by incubation in GTE (100 nM Glycine, 10 MM Tris-HCl, pH 8.0, 1 mM EDTA) at 55 °C for 72 h. During this step, the extraction was checked, and GTE was replaced every 24 h. A negative control was used in the extraction. Sample VNMN 011227 was extracted following Janssen *et al.*'s (2019) protocol.
Extracted DNA was amplified by HotStar Taq PCR Mastermix (Qiagen, Germany) with 21 µl volume (10 µl of mastermix, 5 µl of water, 2 µl of each primer at 10 pmol/ml and 2 µl of DNA). PCR condition was: 95 °C for 15 minutes to active the taq followed by 40 cycles at 95 °C for 30 s, 45 °C for 45 s, 72 °C for 60 s and the final extension at 72 °C for 6 minutes. The PCR products were then used as a template for the new PCR reactions by DreamTaq Mastermix (ThermoFisher Scientific, Lithuania) with the same volume and PCR conditions. Negative controls were used in all amplifications to check for possible contamination. PCR products were visualized using electrophoresis through a 2% low melting-point agarose gel stained with ethidium bromide. Successful amplifications were purified to eliminate PCR components using GeneJET™ PCR Purification kit (ThermoFisher Scientific, Lithuania). Purified PCR products were sent to FirstBase (Malaysia) for sequencing in both directions.
Genomic DNA of sample CIB 115609 was extracted from macerated liver tissue samples using an Ezup Column Animal Genomic DNA Purification Kit (Sangon Biotech, China), according to the manufacturer's protocol. Mitochondrial cytochrome *b* (cyt *b*) was targeted and amplified using primers L14910 and H16064 (Burbrink *et al.*, 2000) (Table 1). Polymerase chain reactions (PCR) were performed with 25 µl volume, and the PCR condition was initial denaturing for 7 min at 94 °C, 41 cycles of denaturation for 40 s at 94 °C, annealing for 30 s at 46 °C, extension for 1 min at 72 °C, and final extension for 8 min at 72 °C. PCR products were purified using a commercial kit and sequenced in both directions by an ABI 3730xL sequencer (Applied Biosystems,

Table 2. Locality, sex and scalation of the newly collected specimens of *Lycodon pictus* from Vietnam and China.

	VNMN 011227	CIB 115609
Locality	Ha Lang, Cao Bang, Vietnam	Nonggang, Guangxi, China
Sex	Female	Female
TL	572	591
SVL	450	467
TaL	125	124
TaL/TL	0.219	0.210
Teeth max	12	13
SL	8	8
SL/orbit	3-5	3-5
IL	10	10/9
PreOc	1	1
PostOc	2	2
Lor	1	1
Lor/eye	no	yes/no
Atem	1(2)	1
PTem	3	3
DSR	17-17-15	17-17-15
PreVen	1	1
Ven	215	218
Prec	single	single
Subc	85	90
BodySc	smooth	smooth
Dark bands on body	29	29
Light bands on body	29	29
Dark bands on tail	15	14
Light bands on tail	16	14

Foster City, CA, USA). Sequence editing was performed in Geneious Pro 4.8.4 (Kearse *et al.*, 2012).

After sequences were checked and aligned by Sequencher v5.4 (Gene Codes Corp, Ann Arbor, MI, USA), they were compared with those generated by Janssen *et al.* (2019) using BLAST (Basic Local Assignment Search Tool) (McGinnis & Madden, 2004) on GenBank. For sample IEBR 4166, after removing the primers, the cytochrome *b* fragments, which overlapped by approximately 50 bps, had an average of approximately 200 bps in length. The final sequence was 1117 bps in length. Other two sequences both contained 1056 bps in length. The newly obtained sequences were uploaded on Genbank under accession numbers MT845093-MT845095.

RESULTS

Both specimens, one from the site close to the type locality in Cao Bang Province, Vietnam (VNMN 011227), and the other one from Nonggang, Longzhou County, Guangxi Zhuang Autonomous Region, China (CIB 115609, field no. GX2019069), generally accorded with the morphological diagnosis of *Lycodon pictus* provided by Janssen *et al.* (2019) (see Table 2). Molecular analyses supported the morphological data. Sequences of the new specimens from Nonggang National Nature Reserve, Longzhou County, Guangxi Zhuang Autonomous Region, China (CIB 115609) and from Cao Bang Province, Vietnam were approximately 0.5-0.9% and 0.3-0.9% (cyt *b*) genetically divergent from those of the type series, respectively. Molecular analyses also revealed that the holotype IEBR 4166 (Field number CB.2012.97) of *Lycodon pictus* Janssen, Pham, Ngo, Le, Nguyen & Ziegler, 2019 showed about 0.9-1.3% differentiation from the remaining type series and 0.5% from VNMN 011227. The Guangxi's sequence is roughly 0.9% differentiated from the holotype sequence. Nucleotide substitutions were distributed randomly over the sequence derived from the type specimen (IEBR 4166).

TAXONOMIC ACCOUNT

Lycodon pictus Janssen, Pham, Ngo, Le, Nguyen & Ziegler, 2019

Figs 1-3

New record for Vietnam (n = 1): VNMN 011227 (Fig. 1), Ha Lang, Cao Bang, Vietnam, Coordinates 22°42'50" N, 106°40'74" E, 960 m a.s.l., collected by Nguyen Quoc Huy on 18 May 2019.

Fig. 1. The new record of *Lycodon pictus* (VNMN 011227) from Vietnam in life. Photograph by Tao Thien Nguyen.

New record for China (n = 1): CIB 115609 (field no. GX2019069; Figs 2-3), Nonggang National Nature Reserve, Longzhou County, Guangxi Zhuang Autonomous Region, China, 106°57'18.77" E, 22°28'3.92" N, 233 m a.s.l., collected by Ren Jin-Long and Zeng Fan-Xing on 8 July 2019.

Description of the Chinese specimen: Head elongate, moderately distinct from neck, rather flattened, longer than wide, snout narrow, distinctly shorter than head width; nostril large, lateral, located in the middle of the nasal; eye large, pupils vertically elliptic; rostral triangular, much broader than high, hardly visible from above; nasal divided, narrowed medially; two internasals, anteriorly round, slightly wider than high, bordered by two large, hexagonal prefrontals posteriorly; frontal single, enlarged, pentagonal to hexagonal, narrowed posteriorly; parietals large, longer than wide, in contact with each other medially, with upper anterior and posterior temporals, paraparietal laterally and four nuchal scales posteriorly; paraparietals elongated, anterior part widened, about equal in length or slightly longer than posterior temporals; loreal 1/1, elongate, not entering orbit on right side, whereas the posterior corner entering orbit on the left side (Fig. 3C and D); supralabials 8/8, first and second in contact with nasal, third to fifth entering orbit, sixth largest, slightly higher than third on left side; infralabials 10/9, first pair in broad contact with each other, first to fifth/first to fourth in contact with anterior pair of chin shields; anterior and posterior pairs of chin shields elongate, second pair not meeting in midline; preocular 1/1, located on antero-upper part of eye; postoculars 2/2, lowermost smaller, bordering anterior temporals; anterior temporal 1/1, in contact with sixth supralabial; posterior temporals 3/3, upper one thinner than lower one. Left maxilla arched, with an angular apex, distinctly bent inwards anteriorly. A total of 13 maxillary teeth or teeth alveola, with the following formula: five small anterior teeth, slightly enlarged posteriorly + three strongly enlarged teeth, thick, and not much curved + a distinctly wide gap + three small teeth + a small gap + two enlarged posterior teeth.
Body elongate, TL 591 mm; SVL 467 mm; TaL 124 mm; preventral 1, ventrals 218, from behind neck region distinctly notched laterally; subcaudals 90, paired; precloacal plate single; DSR 17-17-15, all smooth; the vertebral scales not enlarged.

Coloration in preservative: Dorsal surface of head and neck with pigmentation, paler on lateral side of head, the lower part of supralabials yellowish cream, speckled

Fig. 2. New country record of *Lycodon pictus* (CIB 115609) from China (Nonggang, Guangxi), adult female in life. Photograph by Jin-Long Ren.

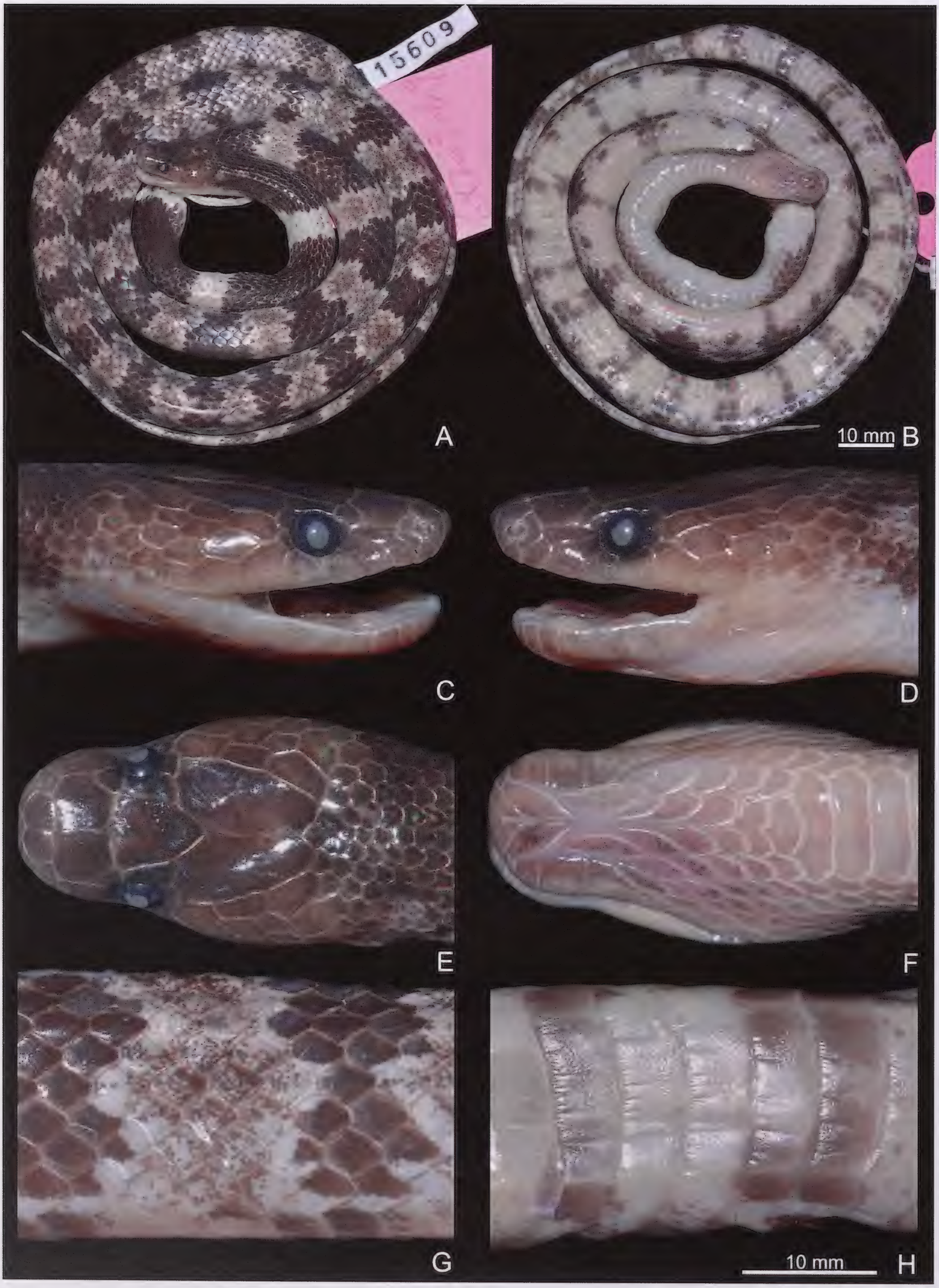


Fig. 3. Adult female of *Lycodon pictus* (CIB 115609; Guangxi, China) in preservative. (A) Dorsal general view; (B) Ventral general view; (C) Lateral head view, right side; (D) Lateral head view, left side; (E) Dorsal view of head; (F) Ventral view of head; (G) Lateral body view; (H) Ventral scale view. Scale bar 5 mm. Photographs by Jin-Long Ren.

with pale brownish blotches. Body brownish black, light body bands beginning after 1.5 times the head length behind the head, in total 29 transverse light bands on body and 14 light bands on tail; the first four body bands yellowish cream, and distinctly widened towards the venter, increased in size posteriorly; a dark mottling in the vertebral region more prominent posteriorly; the subsequent light body bands with two distinct indentations on each side, fused in the middle in the last third of the body.

Ventral surface of head and neck yellowish cream, belly cream and greyish cream in the last third part of body and on lower tail surface; the dark dorsal bands in part extending towards the venter, forming complete dark bands around the posterior body and on the tail; lateral side of the head cream below, with the lighter pattern beginning in the supralabial region; tip of lower jaw and infralabial region in part greyish brown; dorsal surface of the head and upper head sides a bit paler than the remaining head dorsum.

Variation of the new specimens: The Chinese specimen (CIB 115609) largely matches the morphological data of the original description of *Lycodon pictus*, except for having (1) a slightly shorter tail, TaL/TL 0.210 vs 0.215 in the single female paratype; (2) fewer infralabials 9/10 vs 10; (3) fewer anterior temporals 1 vs 2; however, Janssen *et al.* (2019) already documented the condition "2*" each for one side of both paratypes, meaning two anterior temporals with the lowermost not touching the postocular, thus referred to as posterior temporal herein, resulting in only one anterior temporal in afore mentioned cases in the type series already.

The Vietnamese specimen (VNMN011227) generally agrees with the morphological data of the original description of *Lycodon pictus*, except for having (1) a slightly longer tail, TaL/TL 0.219 vs 0.211 to 0.215 in the single juvenile and the single female from the type series for which TaL/TL ratio was available, (2) slightly fewer maxillary teeth (12 vs 13 or 14) and (3) fewer subcaudals 85 vs 90 or 91.

Both specimens showed more bands on the tail; 14 dark bands in CIB 115609 and 15 dark bands in VNMN011227 (vs 9 and 13); 14 light bands in CIB 115609 and 16 light bands in VNMN011227 (vs 9+ and 13).

Extended diagnosis: *Lycodon pictus* can be differentiated from its congeners by the following morphological characters: dorsal scales in 17–17–15 rows, all smooth; supralabials eight (rarely nine); infralabials ten (rarely nine); one elongated loreal on each side, either in contact with the eye or separated from it; precloacal plate single; ventral scales 212-218 (plus one or two preventral scales); subcaudals 85-91; a total length of 597+ mm in males and 543-591 mm in females; tail / total length ratio 0.210-0.219 in females;

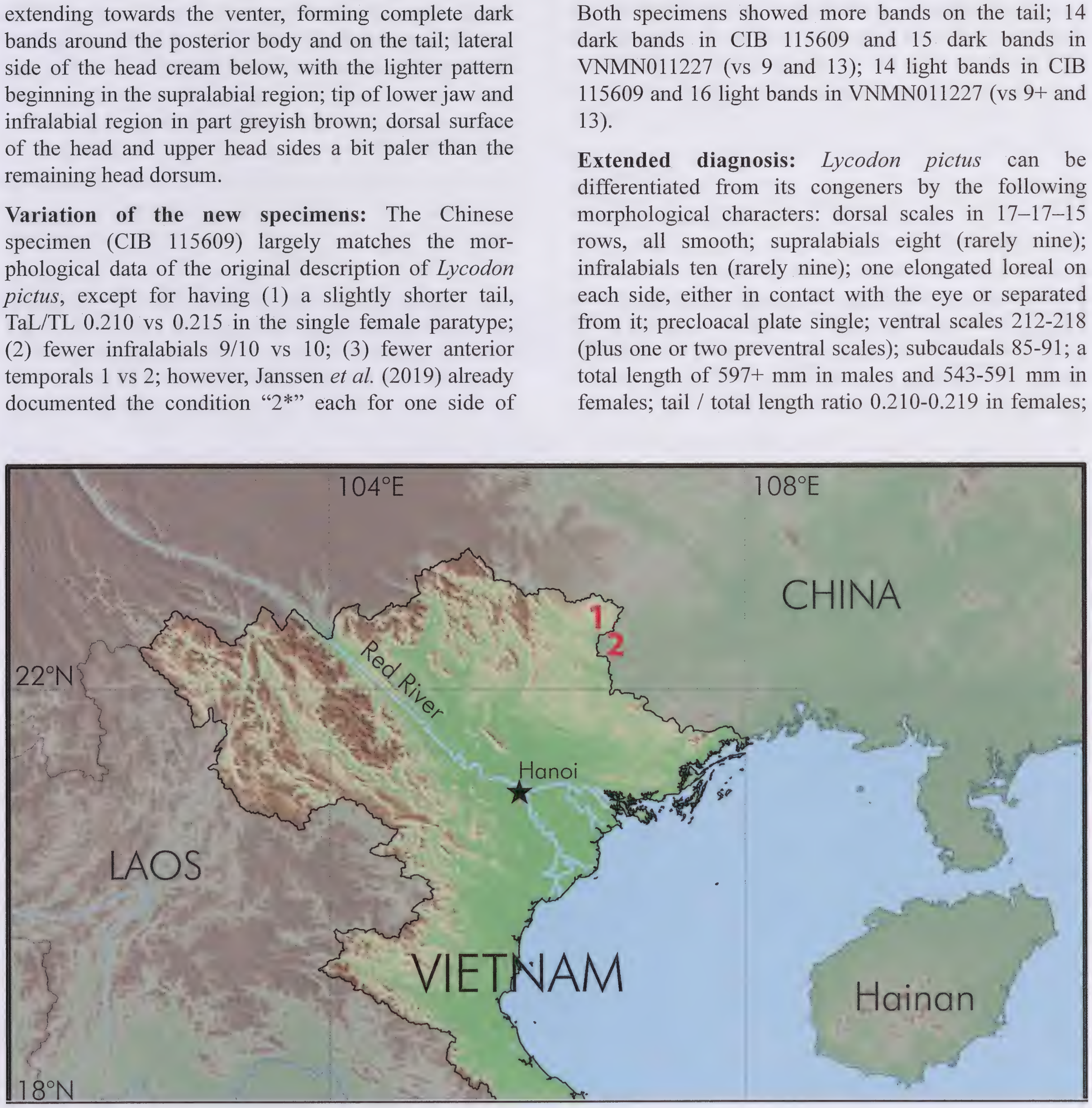


Fig. 4. Map showing the new findings of *Lycodon pictus*. 1: VNMN 011227, from closeby the type locality in Cao Bang Province, northern Vietnam. 2: CIB 115609, the new country record of *L. pictus* from Nanggong, Guangxi, southern China.

maxillary teeth 12 to 14; dorsal surface of body with 28 or 29 light body bands; dorsal surface of tail with 9 to 15 dark bands, and 13 to 16 cream bands forming a distinct blotch in the vertebral region; ventral surface of body and tail mostly cream with the dark body bands in part extending towards the venter, sometimes forming complete dark bands around the body.

Distribution: *Lycodon pictus* is currently known from the type locality in Cao Bang Province, northern Vietnam and Longzhou County in Guangxi, southern China (Fig. 4).

Etymology: The specific name of the species, "*pictus*", meaning painted or decorated in Latin, refers to the unique dorsal color pattern of this species (Janssen *et al.*, 2019). Because this species is herein reported as a new member of the Chinese snake fauna, we suggest "Jin Bai Huan She (锦白环蛇)" as its Chinese common name, deriving from its scientific name.

Natural history: *Lycodon pictus* inhabits karst environment in between elevations of 233 m (Nonggang, Guangxi, China, this study, Fig. 5) and 701 m a.s.l. (type locality; Janssen *et al.,* 2019). In southern China, the species was found at night between 00:00 and 1:00 am after light rain, active in a drainage ditch along a forest path, covered with dead leaves. The surrounding habitat was secondary karst forest, consisting of short hardwood, shrubs and vines. The snake did not attempt to bite when it was handled, neither aggressive nor defensive behavior was observed. In terms of the herpetofauna, several other amphibians and reptiles were observed during the survey period in 2019 in the same microhabitat, including *Kurixalus odontotarsus* (Ye & Fei in Ye *et al.*, 1993), *Rhacophorus kio* (Ohler & Delorme, 2006), *Draco maculatus* (Gray, 1845), *Acanthosaura lepidogaster* (Cuvier, 1829), *Goniurosaurus luii* Grismer, Viets & Boyle, 1999, and *Psammodynastes pulverulentus* (Boie, 1827).

DISCUSSION

The holotype of *Lycodon pictus* (IEBR 4166) could be genetically confirmed. The newly discovered specimen from the site close to the type locality in northern

Fig. 5. Macrohabitat of *Lycodon pictus* in Nonggang National Nature Reserve, Longzhou, Guangxi, China. Photograph by Jin-Long Ren.

Vietnam only differed slightly from the original diagnosis of *Lycodon pictus* in a somewhat lower number of subcaudals (85 vs 90 or 91 in the original diagnosis), a tail / total length ratio of 0.219 (vs 0.211-0.215 in the original diagnosis), more tail bands (16 vs 13 light bands, and 15 vs 9 to 13 dark bands) and 12 or 13 (vs 13 or 14) maxillary teeth. The new record from China deviates from the original description in having fewer infralabials (9/10 vs 10) and a slightly smaller TaL / TL ratio (0.210 vs 0.211-0.215 in the original diagnosis). The slight morphological differences are evaluated by us as being within infraspecific variation, in particular given the low number of specimens of *L. pictus* known so far. The high level of molecular similarity between the new records and the type series affirm their conspecific status. In the original description the loreal was mistakenly given as in contact with the eye both in the abstract and in the diagnosis. This study confirms that the loreal both can be in contact or not with the eye in this species. This represents not only an extended morphological diagnosis of *L. pictus* but also the first country record of *Lycodon pictus* from China, which increases the known species number from China to 17 (Wang *et al.*, 2020a, b). The location of the new record of *L. pictus* from China is approximately 60 km apart from the type locality in Vietnam.

ACKNOWLEDGEMENTS

We thank the Nonggang National Nature Reserve (China) for the support in specimen collection; Zeng Fan-Xing, Chen Tian-Bo, Rao Hua, Huang Zhi-Qiang for their help in the field. Field study in China was supported by the National Natural Science Foundation of China Grants 31722049 and 31772434 and the International Partnership Program of Chinese Academy of Sciences (151751KYSB20190024). We are grateful to the directorate of the Forest Protection Department of Cao Bang Province (Vietnam) for support of our field work and issuing relevant permits. We thank E. Sterling (New York) and K. Koy (Berkeley) for providing the map. Field work in northern Vietnam was funded by the Vietnam Academy of Science and Technology (QTRU01.06G19-20) and the Nagao Natural Environment Foundation (NEF) - CGF Programme to Tao Thien Nguyen.

REFERENCES

Anderson J. 1879. Reptilia and amphibia. *In:* Anatomical and Zoological Researches: Comprising an Account of the Zoological Results of the Two Expeditions to Western Yunnan in 1868 and 1875. Volume I. [pp 703-860, 969-975 index.]. *Bernard Quarich, London*, Vol. I: 705-860 [1878].

Blanford W.T. 1878. Notes on some Reptilia from the Himalayas and Burma. *Journal of the Asiatic Society of Bengal* (2) 47: 125-131.

Boie F. 1827. Bemerkungen über Merrem's Versuch eines Systems der Amphibien, 1. Lieferung: Ophidier. *Isis van Oken* 20: 508-566.

Bourret R. 1935. Notes herpétologiques sur l'Indochine française. IX. Les Serpents de Chapa. *Bulletin général de l'Instruction publique,* 14 (1934-1935), 7 (Mars), 239-251 [Reprint: 5-17].

Burbrink F.T., Lawson R., Slowinski J. B. 2000. Mitochondrial DNA phylogeography of the polytypic North American rat snake (*Elaphe obsoleta*): a critique of the subspecies concept. *Evolution* 54: 2107-2118.

Cantor T. 1842. General features of Chusan, with remarks on the flora and fauna of that island [part 1]. *Annals & Magazine of Natural History* (1)9: 265-278.

Cuvier G.L. 1829. Le Règne Animal Distribué, d'après son Organisation, pour servir de base à l'Histoire naturelle des Animaux et d'introduction à l'Anatomie Comparée. Nouvelle Edition [second edition]. Vol. 2. Les Reptiles. *Déterville, Paris*, i-xvi, 1-406.

Daltry J.C., Wüster W. 2002. A new species of wolf snake (Serpentes: Colubridae: *Lycodon*) from the Cardamom Mountains, southwestern Cambodia. *Herpetologica* 58(4) 498-504.

Dowling H.G. 1951. A proposed standard system of counting ventral in snakes. *Journal of Herpetology* 1: 97-99.

Figueroa A., McKelvy A.D., Grismer L.L., Bell C.D., Lailvaux S.P. 2016. A species-level phylogeny of extant snakes with description of a new colubrid subfamily and genus. *PLoS ONE* 11: e0161070. DOI: 10.1371/journal.pone.0161070

Friedman M., Desalle R. 2008. Mitochondrial DNA extraction and sequencing of formalin-fixed archival snake tissue. *Mitochondrial DNA* 19(5): 433-437.

Günther A.C.L.G. 1864. The reptiles of British India. *Ray Society, London*, xxvii + 452 pp., pls 1-26.

Günther A.C.L.G. 1875. Second report on collection of Indian reptiles obtained by the British Museum. *Proceedings of the Zoological Society of London* 1875 (March): 224-234, pls 30-34.

Guo P., Zhang L., Liu Q., Li C., Pyron R.A., Jiang K., Burbrink F.T. 2013. *Lycodon* and *Dinodon*: one genus or two? Evidence from molecular phylogenetics and morphological comparisons. *Molecular Phylogenetics and Evolution* 68: 144-149.

Gray J.E. 1845. Catalogue of the specimens of lizards in the collection of the British Museum. *Trustees of the British Museum/Edward Newman, London*: xxvii + 289 pp.

Grismer L., Viets B.E., Boyle L.J. 1999. Two new continental species of *Goniurosaurus* (Squamata: Eublepharidae) with a phylogeny and evolutionary classification of the genus. *Journal of Herpetology* 33(3): 382-393.

Hu S., Djao [Zhao] E., Huang Z. 1975. Three new species of reptiles from Hainan Island, Guangdong Province (in Chinese with English abstract). *Acta Zoologica Sinica*, Peking 21(4): 379-384. [English translation by Koshikawa A (1982) Smithsonian Herpetological Information Service, Washington 53: 1-9]

Janssen H.Y., Pham C.T., Ngo H.T., Le M.D., Nguyen T.Q., Ziegler T. 2019. A new species of *Lycodon* Boie, 1826 (Serpentes, Colubridae) from northern Vietnam. *Zookeys* 875: 1-29.

Kearse M., Moir R., Wilson A., Stones-Havas S., Cheung M., Sturrock S., Buxton S., Cooper A., Markowitz S., Duran C., Thierer T., Ashton B., Meintjes P., Drummond A. 2012. Geneious basic: An integrated and extendable desktop

software platform for the organization and analysis of sequence data. *Bioinformatics* 28: 1647-1649.

Lanza B. 1999. A new species of *Lycodon* from the Philippines, with a key to the genus (Reptilia Serpentes Colubridae). *Tropical Zoology* 12: 89-104.

Luu V.Q., Bonkowski M., Nguyen T.Q., Le M.D., Calame T., Ziegler T. 2018. A new species of *Lycodon* Boie, 1826 (Serpentes: Colubridae) from central Laos. *Revue suisse de Zoologie* 125(2): 263-276.

Luu V.Q., Ziegler T., Ha N.V., Le M.D., Hoang T.T. 2019. A new species of *Lycodon* Boie, 1826 (Serpentes: Colubridae) from Thanh Hoa Province, Vietnam. *Zootaxa* 4586: 261-277.

McGinnis S., Madden T.L. 2004. BLAST: at the core of a powerful and diverse set of sequence analysis tools. *Nucleic Acids Res*. 32: W20-W25.

Neang T., Hartmann T., Hun S., Souter N.J., Furey N.M. 2014. A new species of wolf snake (Colubridae: *Lycodon* Fitzinger, 1826) from Phnom Samkos Wildlife Sanctuary, Cardamom Mountains, southwest Cambodia. *Zootaxa* 3814(1): 068-080.

Ohler A., Delorme M. 2006. Well known does not mean well studied: Morphological and molecular support for existence of sibling species in the Javanese gliding frog *Rhacophorus reinwardtii* (Amphibia, Anura). *Comptes Rendus Biologies* 329: 86-97.

Pope C.H. 1928a. Seven new reptiles from Fukien Province, China. *American Museum Novitates* 320: 1-6.

Pope C.H. 1928b. Four new snakes and a new lizard from South China. K 325: 1-4.

Siler C.D., Oliveros C.H., Santanen A., Brown R.M. 2013. Multilocus phylogeny reveals unexpected diversification patterns in Asian Wolf Snakes (Genus *Lycodon*). *Zoologica Scripta* 42: 262-277.

Smith M.A. 1943. The fauna of British India, Ceylon and Burma, including the whole of the Indo-chinese subregion. Reptilia and Amphibia. Vol. III. Serpentes. *Taylor & Francis, London*, xii + 583 pp.

Uetz, P., Freed, P. & Hošek, J. (eds.) 2020. The Reptile Database, http://www.reptile-database.org, accessed 27 July 2020.

Vogel G., David P., Pauwels O.S.G., Sumontha M., Norval G., Hendrix R., Vu N.T., Ziegler T. 2009. A revision of *Lycodon ruhstrati* (Fischer 1886) auctorum (Squamata Colubridae), with the description of a new species from Thailand and a new subspecies from the Asian mainland. *Tropical Zoology* 22: 131-182.

Wang K., Ren J.-L., Chen H.-M., Lyu Z.-T., Guo X.-G., Jiang K., Chen J.-M., Li J.-T., Guo P., Wang Y.-Y., Che J. 2020a. The updated checklists of amphibians and reptiles of China. *Biodiversity Science* 28 (2): 189-218. (in Chinese)

Wang J., Qi S., Lyu Z.-T., Zeng Z.-C., Wang Y.-Y. 2020b. A new species of the genus *Lycodon* (Serpentes, Colubridae) from Guangxi, China. *ZooKeys* 954: 85-108.

Ye C., Fei L., Hu S. 1993. Rare and economic amphibians of China. *Sichuan Publishing House of Science & Technology, Chengdu*, 412 pp. [in Chinese]

Ziegler T., Ngo H.N., Pham A.V., Nguyen T.T., Le M.D., Nguyen T.Q. 2018. A new species of *Parafimbrios* from northern Vietnam (Squamata: Xenodermatidae). *Zootaxa* 4527(2): 269-276.

Revue suisse de Zoologie (September 2020) 127(2): 423-453 ISSN 0035-418

New euagrid spider species from Thailand and Malaysia, and new localities of *Leptothele bencha* (Arachnida: Araneae)

Peter J. Schwendinger[1*], Christina Lehmann-Graber[1], Komson Hongpadharakiree[2] & Nurul Syuhadah[3]

[1] *Muséum d'histoire naturelle de Genève, C.P. 6434, CH-1211 Genève 6, Switzerland*
[2] *Sirinath Rajini Mangrove Ecosystem Learning Center, Pranburi, Prachuab Khiri Khan, Thailand*
[3] *The Liphistius Project, Petaling Jaya, Malaysia*
* *Corresponding author: peter.schwendinger@ville-ge.ch*

Abstract: *Leptothele chang* Schwendinger, sp. nov. (males and females) is described and additional localities of *L. bencha* Raven & Schwendinger, 1995 in southern Thailand are given. *Malayathele* Schwendinger, gen. nov. is established, and four new species from Peninsular Malaysia are placed in this genus. These are *M. cameronensis* Schwendinger, sp. nov. (male and female), *M. kanching* Schwendinger, sp. nov. (males and females), *M. maculosa* Schwendinger, sp. nov. (males and females) and *M. ulu* Schwendinger, sp. nov. (males and females). Identification keys to the genera of Euagridae in Asia and to the species of *Leptothele* and *Malayathele* gen. nov. are given. Information on variation of taxonomic characters, biology, sexual behaviour and biogeography is provided.

Keywords: Taxonomy - Mygalomorphae - Euagridae - Masteriinae - *Phyxioschema* - variation - distribution - biology - mating behaviour.

INTRODUCTION

Leptothele was established as a monotypic genus by Raven & Schwendinger (1995: 637) and regarded as sister to the American genus *Euagrus* Ausserer, 1875 plus the Asian genus *Phyxioschema* Simon, 1889. All three genera share the synapomorphic presence of a retrodorsal band of hooked spinules on femur I and of a retroventral band on femur II of males (used to lock legs I and II together during mating; Coyle, 1986), as well as the presence of a medioventral spur carrying megaspines on tibia II of males (Coyle, 1988; Raven, 1981a; Raven & Schwendinger, 1995). Originally described in the family Dipluridae, *Euagrus*, *Phyxioschema* and *Leptothele* were recently transferred to the family Euagridae Raven, 1979, which was established as a tribe (then spelled Evagrini), later elevated to a subfamily by Raven (1985) and recently to a family by Opatova *et al.* (2020) on the basis of a purely genomic analysis which did not include *Phyxioschema* and *Leptothele* (Opatova *et al.*, 2020: fig. 3). Twelve genera and 81 species were previously placed in this family (World Spider Catalog, 2020); here one genus and five species are added.

Raven & Schwendinger (1995: 637) stated that the dentition of the unpaired leg claws in *Leptothele bencha* is intermediary between the condition in the diplurid subfamily Masteriinae (all teeth set on a common raised base) and the Euagrinae (all teeth sessile on the claw) (Raven, 1985: fig. 6 and table 7). In *L. bencha* the distalmost tooth is sessile on the claw, whereas the remaining teeth are on a common, yet quite low base. The illustrated unpaired claw is that of leg I (Raven & Schwendinger, 1995: fig. 3F). The same was also found in one of the newly collected *L. bencha* specimens (a female from Ko Siray), but only on the anterior legs (Fig. 1E showing the unpaired claw of leg I). On leg III, however, all teeth are clearly sessile on the claw (Fig. 1F). The reverse situation can be seen in *L. chang* sp. nov.: leg I has all teeth sessile on the claw (Fig. 1G) and leg III has the proximal teeth raised on a low common base (Fig. 1H). The same situation is also found in *Phyxioschema huberi* Schwendinger, 2009 (Fig. 1C-D) and in *Malayathele ulu* sp. nov. (Fig. 1I-J). For *P. spelaeum* Schwendinger, 2009 another variant was illustrated: the three distal teeth on leg IV are sessile, whereas the basal five teeth are on an indistinct common base (Schwendinger, 2009: fig. 21D). So it seems to be a shared trait in the genera *Phyxioschema*, *Leptothele* and *Malayathele* gen. nov. that

Manuscript accepted 26.08.2020
DOI: 10.35929/RSZ.0031

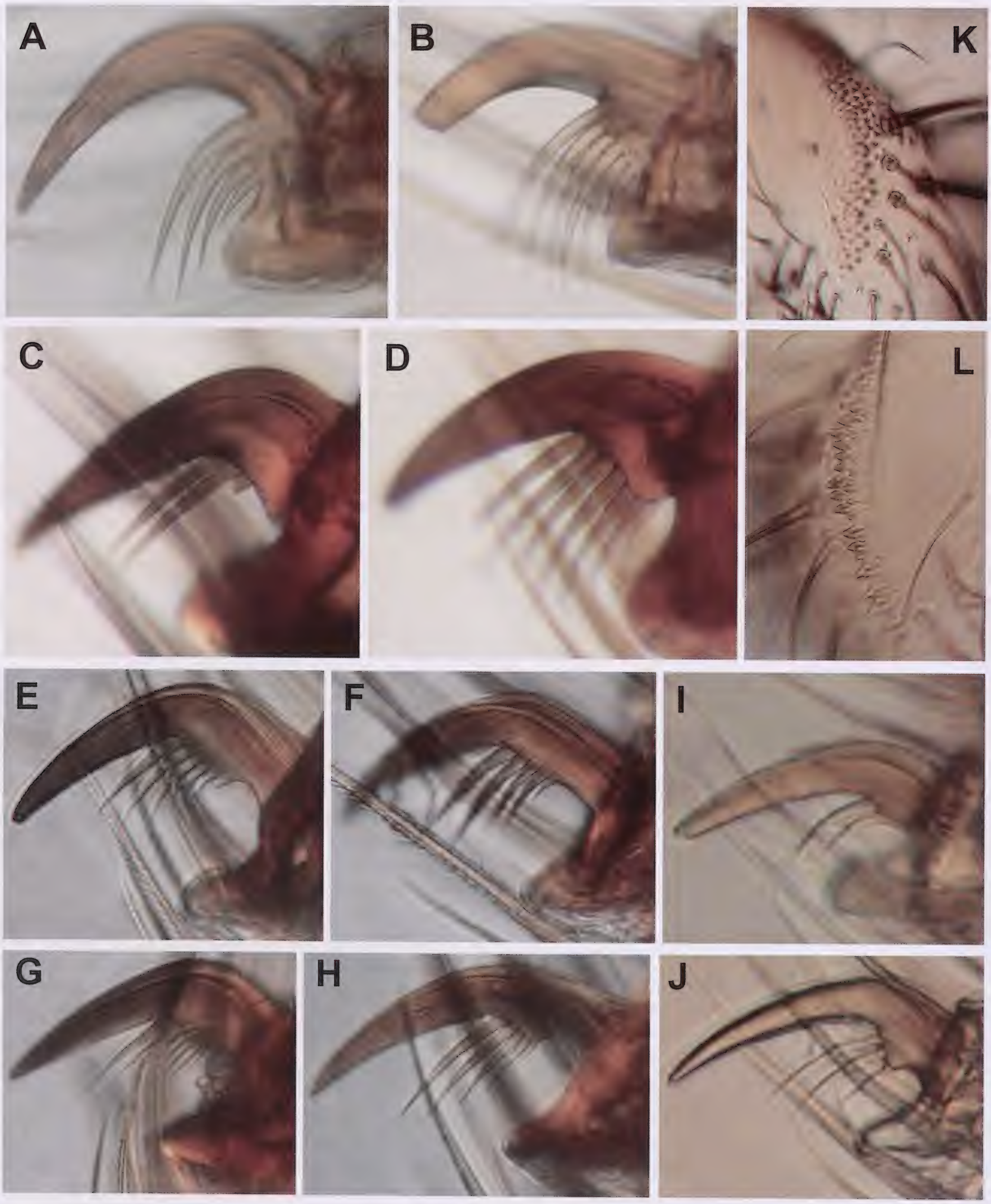


Fig. 1. Photos of unpaired leg claws, lateral view (A-J), and of serrula on palpal coxa, anteroventral view (K-L). (A) *Masteria* cf. *cavicola* (Simon, 1892), female (in MHNG; 13.IV.1977; leg. P. Strinati & V. Aellen) from a cave near Bagio, Luzon, the Phillipines, leg II. (B) Same, leg IV. (C) *Phyxioschema huberi* Schwendinger, 2009, exuvia of female paratype, leg I. (D) Same, leg IV. (E) *Leptothele bencha*, female from Ko Sirey, leg I. (F) Same, leg III. (G) *Leptothele chang* sp. nov., exuvia of female paratype, leg I. (H) Same, leg III. (I) *Malayathele ulu* sp. nov., exuvia of female paratype, leg I. (J) Same, leg IV. (K) *Leptothele chang* sp. nov., exuvia of female paratype. (L) *Malayathele kanching* sp. nov., exuvia of female paratype. Not to scale.

some teeth on the unpaired claws of some legs are set on a common base, and this does "severely test" the distinction between Euagrinae and Masteriinae with regards to the dentition of the unpaired claw (Raven & Schwendinger, 1995: 637). Further muddying the waters is a female specimen of *Masteria* sp. [presumably *M. cavicola* (Simon, 1892)] from a cave in the Philippines, deposited in the MHNG, that does not have all teeth of the unpaired claws of leg II and IV raised on a common base (Fig. 1A-B) – certainly not those of leg II (Fig. 1A). This is quite different from the typical masteriine dentition illustrated for *Masteria magna* Raven, 1981b and *Striamea gertschi* Raven, 1981b in which all teeth are clearly raised on a distinct common base (Raven, 1981b: fig. 24, and Raven, 1981b: fig. 23 as well as Passanha & Brescovit, 2018: fig. 35B, respectively). At the moment, and without a more comprehensive comparative study, the morphology of the unpaired claw cannot be considered as a reliable character for the distinction of family-level taxa in the Dipluridae and Euagridae.

The geographical ranges of *Leptothele* and *Phyxioschema* slightly overlap in Krabi Province, southern Thailand (Fig. 2; Schwendinger, 2009: fig. 1). However, in that contact zone the ecological niches of both genera are quite different: *L. bencha* builds tiny webs in small spaces in the soil and leaf litter on mostly granite bedrock, whereas all *Phyxioschema* spp. in southern Thailand live in quite large (comparable to those of *Macrothele* spp.) webs in holes and cracks of limestone cliffs, cave walls and speleothems. *Leptothele* was previously known from only a single species, *L. bencha*, and only from the type locality in southern Thailand. In the meantime this species has been collected at several other localities in that area, and specimens of five additional, quite closely related euagrid species were discovered further to the south on the Thai-Malay Peninsula. These are treated in the following.

MATERIAL AND METHODS

Methods: Morphological characters were studied and drawn mainly with a Zeiss SV11 stereomicroscope and an attached drawing tube, the vulvae and claws with a Nikon Optiphot and a Zeiss Axioskop compound microscope with attached drawing tubes. Female copulatory organs were mostly examined from alcohol-preserved specimens after making the dissected parts transparent by first dipping them into cold KOH for less than a minute and then drawing them in lactic acid without removing the gland tissue because clearing off the surrounding gland tissue results in the collapse of receptacular heads. Body measurements are all in mm (for other measurements the units are given) and were taken on the dorsal side, between midpoint of anterior and posterior margin. Total length includes chelicerae and anal tubercle, but not the spinnerets. Leg and palp measurement are given in the following manner: total length (femur + patella + tibia + metatarsus + tarsus). Spine counts taken from both sides of the body (e.g. left and right tibia I) are separated by a forward slash. Terminology follows that used in Raven & Schwendinger (1995) and Schwendinger (2009). In the paragraph "Variation" only taxonomic characters considered to be relevant are mentioned. Hairs and weak bristles are not shown in the drawings of male characters. In the figure legends references to illustrations that are to the same scale are separated by commas, references to illustrations of different scales by semi-colons. The species are presented in geographical order, from north to south.

Museum acronyms: The museums holding type specimens and non-type specimens are given by acronyms in the paragraphs on material examined for each species. MHNG = Muséum d'histoire naturelle de Genève, Switzerland; NHMS = Lee Kong Chian Natural History Museum, Singapore; QMS = Queensland Museum, Brisbane, Australia; THNHM = Thailand Natural History Museum, Pathumthani, Thailand.

Other abbreviations used in the text: ALE = anterior lateral eyes; AME = anterior median eyes; d = dorsal; MOQ = median ocular quadrangle; p = prolateral; PLE = posterior lateral eyes; PLS = posterior lateral spinnerets; PME = posterior median eyes; PMS = posterior median spinnerets; r = retrolateral; v = ventral. Additional abbreviations are explained in the corresponding figure legends.

TAXONOMY

Euagridae Raven, 1979

Diagnosis: See Raven, 1985: 78-79.

Leptothele Raven & Schwendinger, 1995

Leptothele Raven & Schwendinger, 1995: 636-637.

Type species: *Leptothele bencha* Raven & Schwendinger, 1995 by monotypy and by designation.

Species included: *Leptothele bencha* Raven & Schwendinger, 1995 and *L. chang* sp. nov.

Revised diagnosis: Distinguished from *Phyxioschema* by males lacking a prolateral band of elongated spinules and by possessing a much shorter ventral spur (Figs 3B, E, 5E, 6G cf. Raven, 1981: fig. 7; Schwendinger, 2009: figs 2D, 4C, 5C, 9C, 12C, 15C) and a low transversal subdistal ventral ridge on tibia II (Figs 3B-C, E-F, I-J, 5E, 6G-K), and by possessing a single, widely conical or mound-like ventral process instead of 2-3 longitudinal ridges on metatarsus II (Figs 3B-C, E-F, I-J, 5E, 6G-I cf. Raven, 1981a: fig. 7; Schwendinger, 2009: figs 2D, 6J, 10J, 13J, 16K, 19L). Females with

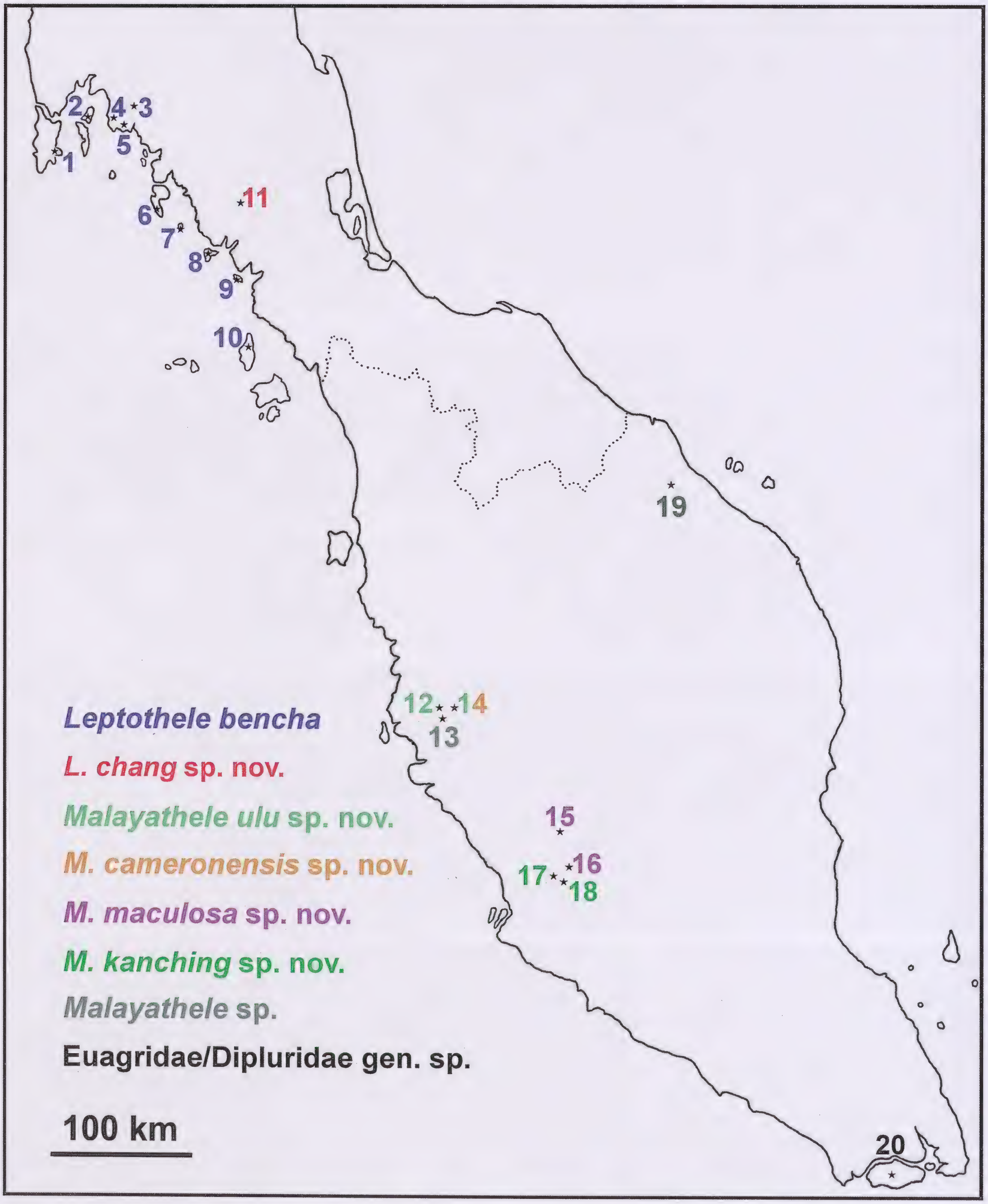


Fig. 2. Localities of *Leptothele* spp. and *Malayathele* spp. on the Thai-Malay Peninsula. The coast of Sumatra is omitted. 1 - Ko Sirey (*L. bencha*); 2 - Ko Yao Noi (*L. bencha*); 3 - Khao Phanom Bencha (*L. bencha*, type locality); 4 - Thab Khaek - Hang Nak Hill and Khlong Jilat (*L. bencha*); 5 - Ban Chong Phlie (*L. bencha*); 6 - Ko Lanta (*L. bencha*); 7 - Ko Muk (*L. bencha*); 8 - Ko Libong (*L. bencha*); 9 - Ko Sukon (*L. bencha*); 10 - Ko Tarutao (*L. bencha*); 11 - Tham Khao Chang Hai (*L. chang* sp. nov., type locality); 12 - Ulu Groh (*M. ulu* sp. nov., type locality); 13 - Chenderiang (*Malayathele* sp.); 14 - Cameron Highlands (*M. cameronensis* sp. nov., type locality; *M. ulu* sp. nov.); 15 - Fraser's Hill (*M. maculosa* sp. nov., type locality); 16 - Genting Highlands (*M. maculosa* sp. nov.); 17 - Templer Park (*M. kanching* sp. nov.; type locality); 18 - Ulu Gombak (*M. kanching* sp. nov.); 19 - Jeram Pasu Waterfall (*Malayathele* sp.); 20 - Singapore (Euagridae/Dipluridae gen. sp.).

Key to the genera of Euagridae in Asia:

1A Males with a band of elongated spinules on prolateral side of tibia II (Raven, 1981a: fig. 7), with a distinct, quite long spur (carrying megaspines) on ventral side of tibia II, and with 2-3 longitudinal keels on ventral side of metatarsus II (proventral one reduced to a small cone in *P. sayamense* Schwendinger, 2009: fig. 13I-J); patella I with a row of short, sigmoid or (rarely) curved retroventral-distal spines (Schwendinger, 2009: figs 3L, 6F, 10F, 13F, 16F); femur II with a long proventral band of hooked spinules (almost or actually reaching distal margin of leg article; Schwendinger, 2009: figs 2B, 4E, 5E, 9E, 12E, 15E, 18E); palpal tarsus with strong distal bristles (not spines; Schwendinger, 2009: fig. 2C). Females with or without secondary receptacles, if present then situated posterior of median receptacles (Schwendinger, 2009: figs 3A-I, 7, 11, 14, 17, 20; Schwendinger & Zonstein, 2011: figs 4-5, 8). Both sexes usually with spines on tarsi of posterior legs (most males of *P. suthepium* Raven & Schwendinger, 1989 and some *P. eripnastes* Schwendinger, 2009 without). Central Asia and all over Thailand..... ..... *Phyxioschema*

1B Males without a band of elongated spinules on prolateral side of tibia II (Figs 5E, 12G), with a rather indistinct short spur (carrying megaspines) on ventral side of tibia II, and with 1-2 mound-like, conical or tooth-shaped processes on ventral side of metatarsus II (exception: a short retroventral keel in *M. cameronensis* sp. nov., Fig. 11G-J); patella I with a row of long, not sigmoid bristles (Figs 6F, 8F, 11F, 13I) or with only a single curved spine retroventrally-distally (Fig. 15E); femur II with a short proventral band of hooked spinules (distant from distal margin of leg article; Figs 5F, 10B); palpal tarsus with distinct distal spines (Figs 3A, D, H, 6B-E, 8A-E, 11A-D, 15A-C). Females without secondary receptacles (Figs 4, 7, 9, 11K, 16), if exceptionally present, then situated anterior of median receptacles (Fig. 7C). Both sexes without spines on tarsi of posterior legs. Southern Thailand and Peninsular Malaysia 2

2A Small body size (carapace length in males 1.52-2.73), distal article of PLS pseudosegmented (Fig. 5I), no metatarsal preening combs in both sexes. Males with at least two megaspines and with a transversal subdistal ridge on ventral side of tibia II (Figs 3B-C, E-F, I-J, 5E, 6G-K); metatarsus II with a single conical or mound-like process on ventral side (Figs 3B-C, E-F, I-J, 5E, 6G-I); tarsi I-II not ventrally bulged (Fig. 5H). Females with quite long spermathecal trunks; stalks of median receptacles not sclerotised (Figs 4, 7). Southern Thailand ..... *Leptothele*

2B Very small body size (carapace length in males 1.11-1.44), distal article of PLS not pseudosegmented (Fig. 12J-K), metatarsal preening combs present on legs II-IV in both sexes. Males with only one ventral megaspine and without a subdistal ridge on ventral side of tibia II (Figs 8H-K, 10B, 11G-J, 12G, 13J-M, 15F-H); metatarsus II with two small conical processes, a proventral and a retroventral one (Figs 13J-K, M, 15F-H), or with only a small conical retroventral process (Fig. 8I-J), or with a small conical proventral and a keel-shaped retroventral processes (Fig. 11G-J); tarsi I-II ventrally bulged (Fig. 10D). Females with rather short spermathecal trunks; stalks of median receptacles sclerotised (Figs 9, 11K, 14, 16). Peninsular Malaysia ..... *Malayathele* gen. nov.

Key to the species of *Leptothele*:

1A Small body size (carapace lengths in males 1.52-2.04). Males normally with two ventral megaspines (Fig. 3C, F; single asymmetrical exception, Fig. 3J) and always without wrinkles behind and in front of subdistal-ventral ridge on tibia II (Fig. 3C, F, J); ventral process on metatarsus II widely conical (Fig. 3B, E, I); bulbous part of palpal organ as long as wide or wider than long (Fig. 3A, D, H, G). Females with quite long and narrow spermathecal trunks; stalks of median receptacles mostly shorter than corresponding heads (Fig. 4A-D), except for females from Ko Siray (Fig. 4E-F) ..... *L. bencha*

1B Larger body size (carapace lengths in males 2.30-2.73). Males with 2-3 ventral megaspines and with wrinkles behind and in front of subdistal ridge on tibia II (Fig. 6H-K); ventral process on metatarsus II less distinct, developed as a low, wide mound (Fig. 6G); bulbous part of palpal organ longer than wide (Fig. 6A-E). Females with relatively shorter and wider spermathecal trunks; stalks of median receptacles very long and thin, almost twice of corresponding head lengths (Fig. 7) ..... *L. chang* sp. nov.

vulvae quite similar to those of *Phyxioschema* females, but stalks of receptacles not sclerotised and usually no secondary receptacles present [one exception – unsymmetrical and situated anterior of median receptacle – in *L. chang* sp. nov. (Fig. 7C); secondary receptacles in *Phyxioschema*, if present, posterior of or at same level as median receptacle, see Schwendinger, 2009: figs 3A-I, 11, 17 and Schwendinger & Zonstein, 2011: figs 4-5, 8]. Metatarsal preening combs absent (present in *P. suthepium* and *P. erawan* Schwendinger, 2009, but not in other *Phyxioschema*). Distinguished from *Malayathele* gen. nov. by distal article of PLS with a pseudosegmentation (Fig. 5I cf. Fig. 12J-K) and by lacking metatarsal preening combs in both sexes; males with 2-3 (Figs 3C, F, 6H-K; exceptionally more, Fig. 3J) megaspines (only one in *Malayathele* gen. nov., Figs 8I-J, 11I-J, 13J, 15F) and a transversal subdistal ridge (Figs 3B-C, E-F, I-J, 6G-K; absent in *Malayathele* gen. nov.) on ventral side of tibia II, and with a single, widely conical or mound-like median process on metatarsus II (Figs 3B-C, E-F, I-J, 6G-I; 1-2 small conical processes or one conical process plus a short keel-shaped process in *Malayathele* gen. nov., Figs 8H-K, 11G-J, 13J-M, 15F-H); tarsi I-II not ventrally bulged (Fig. 5H cf. Fig. 10D). Females distinguished from those of *Malayathele* gen. nov. by possessing median receptacular stalks with unsclerotised walls (Figs 4, 7 cf. Figs 9, 11K, 14, 16). Revised character: teeth on unpaired leg claws either all sessile (Fig. 1F-G) or proximal teeth raised on indistinct common base (Fig. 1E, H).

Distribution: Southern Thailand (Fig. 2, localities 1-11).

Leptothele bencha Raven & Schwendinger, 1995

Figs 1E-F, 3-4

Leptothele bencha Raven & Schwendinger, 1995: 637-639, figs 2C, 3E-F, 4E, 5F-G, 9 (description of males and females).

Holotype: QMS 29275; male; THAILAND, Krabi Province, Khao Phanom Bencha National Park, near Huay To Waterfall, 8°14'16"N, 98°55'02"E, 260 m; 21.IX.1992; leg. P.J. Schwendinger.

Paratypes: QMS 29276; 3 females; same data as for holotype. – MHNG; 1 male and 1 female; same data as for holotype.

Other material examined: MHNG (sample THMA-00/14); 5 males (matured 17.VIII.2000, 24.IX.2000, beginning XII.2000), 11 females; THAILAND, Phuket Province, Ko Sirey, 7°53'10"N, 98°26'11"E, 50 m; 12.VIII.2000; leg. P.J. Schwendinger. – MHNG (sample TH-02/11); 1 male, 1 female; Ko Sirey, 30 m; 22.VIII.2002; leg. P.J. Schwendinger. – MHNG; 4 females; THAILAND, Krabi Province, Khao Phanom Bencha National Park, near Huay To Waterfall (the type locality), 260 m; 21.IX.1992; leg. P.J. Schwendinger. – MHNG (sample THA-99/1); 1 female; THAILAND, Krabi Province, Khao Phanom Bencha National Park, near Huay To Waterfall, 8°14'24"N, 98°54'56"E, 100-190 m; 11.X.1999; leg. P.J. Schwendinger. – MHNG (sample TH-07/10); 5 females; THAILAND, Phang Nga Province, Ko Yao Noi, 8°11'04"N, 98°38'02"E, 70 m; 16.VII.2007; leg. P.J. Schwendinger. – MHNG (sample TH-06/07); 2 males (one of them matured XII.2006), 2 females; THAILAND, Ko Yao Noi, near Ban An Pao, 8°09'53"N, 98°37'20"E, 150 m; 21.IX.2006; leg. P.J. Schwendinger. – MHNG (sample THMA-08/10); 2 females; THAILAND, Krabi Province & District, Khlong Jilat, 8°05'18"N, 98°52'56"E, 60 m; 16.VI.2008; leg. P.J. Schwendinger. – MHNG (sample THMA-08/07); 1 male (hatched VIII.08, matured end XII.09), 4 females; THAILAND, Krabi Province & District, Thab Khaek - Hang Nak Hill, near waterfall, 8°05'43"N, 98°45'11"E, 300 m; 13.VI.2008; leg. P.J. Schwendinger. – MHNG (sample TH-09/09); 1 female; THAILAND, Krabi Province & District, Ban Chong Phlie, 8°04'50"N, 98°49'50"E, 80 m; 13.VI.2009; leg. P.J. Schwendinger. – MHNG (sample THA-99/3); 3 males (hatched end XII.1999; matured 18.VI.2000, VII.-VIII.2000, IX.2000), 9 females; THAILAND, Krabi Province, Ko Lanta, 7°28'36"N, 99°05'25"E, 5 m; 15.X.1999; leg. P.J. Schwendinger. – MHNG (sample TH-09/03); 2 females; THAILAND, Trang Province, Ko Muk, near Morakot Cave, 7°21'52"N, 99°17'30"E, 60 m; 28.V.2009; leg. P.J. Schwendinger. – MHNG (sample TH-05/09); 4 males (one collected mature, others matured 16.IX.2005, 7.X.2005, 9.XI.2005), 11 females; THAILAND, Trang Province, Ko Libong, near Ao Tokae, 7°16'04"N, 99°22'39"E, 30 m; 20.VII.2005; leg. P.J. Schwendinger. – MHNG (sample TH-09/02); 1 male, 10 females; THAILAND, Trang Province, Ko Sukon, 7°05'51"N, 99°34'53"E, 140 m; 23.V.2009; leg. P.J. Schwendinger. – MHNG; 6 males (matured 13.II.1996, 20.IX.1996, 13.VI.1997, 10.VII.1997, 22.VIII.1997, 27.VIII.1997), 12 females; THAILAND, Satun Province, Ko Tarutao, 6°40'60"N, 99°38'47"E, 30 m; 12.I.1996; leg. P.J. Schwendinger. – THNHM; 1 male (matured 10.IX.1996), 1 female; THAILAND, Satun Province, Ko Tarutao, 30 m; 12.I.1996; leg. P.J. Schwendinger.

Extended diagnosis: Distinguished from *L. chang* sp. nov. by smaller size and darker body colour. Males with shorter bulbous part of palpal organ (Fig. 3A, D, G, H cf. Fig. 6A-E), normally only with two ventral megaspines [Fig. 3C, F (one exception with four megaspines, Fig. 3J); 2-3 megaspines in *L. chang* sp. nov., Fig. 6H-K] and without wrinkles behind and in front of subdistal ventral ridge on tibia II (Fig. 3C, F, J; present in *L. chang* sp. nov., Fig. 6H-K), and with a more distinct, conical ventral process on metatarsus

II (Fig. 3B, E, I cf. Fig. 6G). Females with longer and narrower spermathecal trunks and with much shorter stalks of median receptacles (Fig. 4 cf. Fig. 7).

Variation: Carapace lengths in males (n = 25) range 1.52-2.04, carapace widths 1.29-1.78. The smallest male examined is the paratype deposited in the MHNG, the largest male is from Thab Khaek - Hang Nak Hill. The largest female (from Khlong Jilat) has a 2.94 long and 2.49 wide carapace. Among the 25 males examined 24 have two ventral megaspines on the tibiae of both legs II. Only a single male (from Ko Sukon) has a relatively low ventral spur carrying four megaspines on its left tibia II (Fig. 3I-J), which is clearly abnormal; its right tibia II is equipped with a more elevated (i.e. normal for this species) ventral spur carrying two megaspines. The holotype (not re-examined) appears to lack any proximal spines on the ventral side of metatarsus I of at least the right leg (Raven & Schwendinger, 1995: 638, fig. 9F), but all males examined for this study (including a paratype) have 1-2 weak spines at that position. A male from Ko Libong has a slightly longer bulbal part of the palpal organ (Fig. 3H) than the other conspecific males examined.

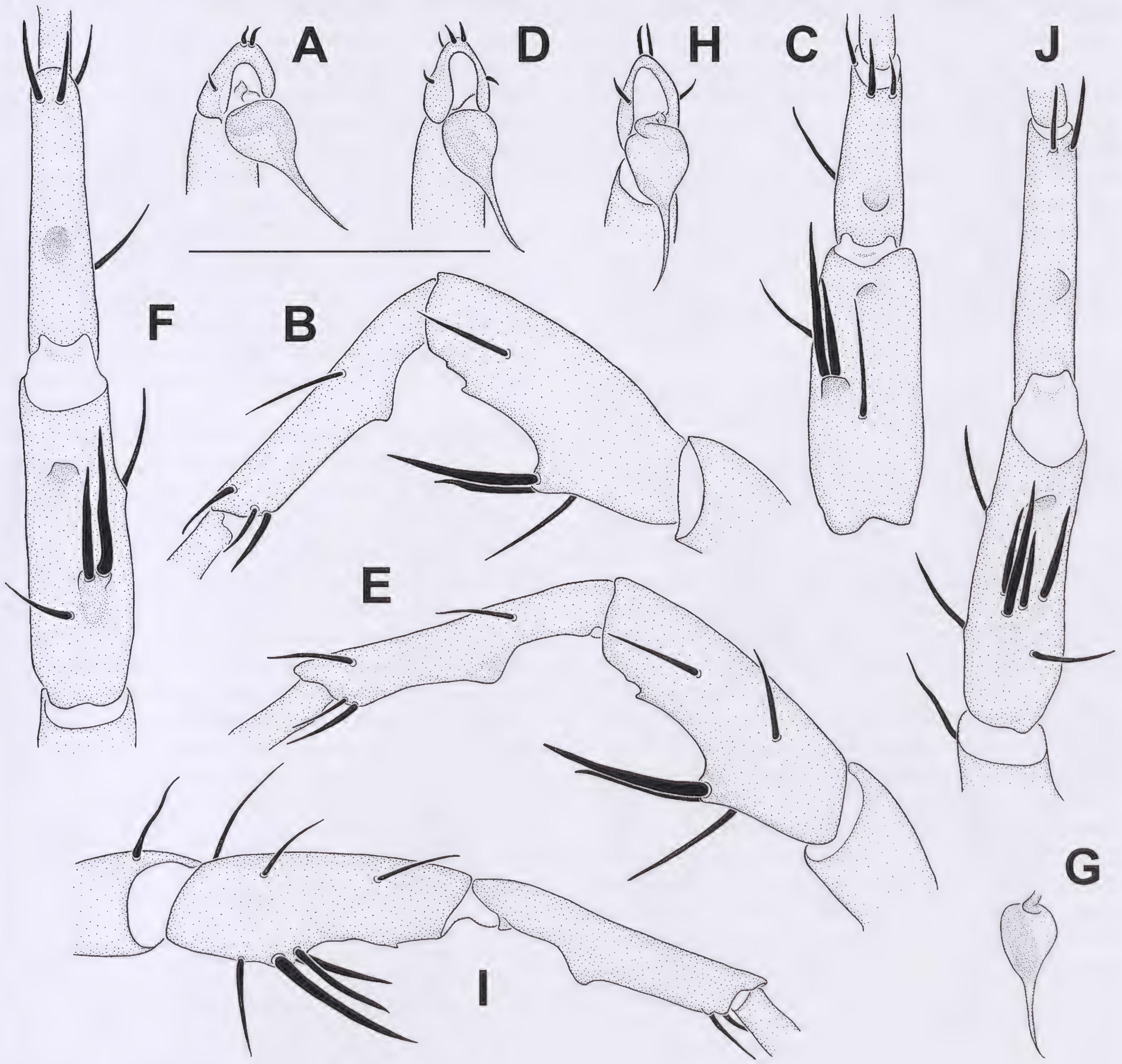


Fig. 3. *Leptothele bencha*; males from Ko Sirey (A-B), Ko Tarutao (C-F, G, showing two specimens), Ko Libong (H) and Ko Sukon (I-J). (A, D, H) Distal part of palp, ventral view. (B, E) Right tibia and metatarsus II, prolateral view. (C) Left tibia and metatarsus II, ventral view. (F) Right tibia and metatarsus II, ventral view. (G) Palpal organ, ventral view. (I) Left tibia and metatarsus II of aberrant specimen, prolateral view. (J) Same, ventral view. Scale line 1.0 mm.

The vulvae of two females from Ko Siray (the northernmost locality of this species; Fig. 4E-F) have median receptacles with relatively smaller heads and much longer stalks, as well as lateral receptacles with a much narrower apex than females from the other localities (Fig. 4A-D). Despite these quite pronounced differences in female genitalia, the males from Ko Siray show no relevant distinctions from the other males examined (Fig. 3A-B cf. Fig. 3C-J). We consider this as a geographical form that does not deserve specific or subspecific rank.

Remark: The "small pointed protuberances" on the spermathecae and receptacles of two paratypes shown in Raven & Schwendinger (1995: 638, fig. 9J-K) are actually the cuticular bases of gland ducts that empty through pores into the interior of the spermathecae (see also Schwendinger & Ono, 2011: figs 56-58, 61-64). These gland duct bases are clearly visible on exuviae (Fig. 7A, showing *L. chang* sp. nov.), but not on unstained vulvae dissected from specimens (only the pores are visible there, Fig. 4, see also Fig. 7B-D showing *L. chang* sp. nov.). These protuberances thus have no or only very limited taxonomic value.

Distribution: This species is known from 11 localities near the Andaman coast of southern Thailand (Fig. 2, localities 1-10, 4 refers to two nearby localities). Four sites (including the type locality) lie on the mainland in Krabi Province, on or near the coast, the others are on islands quite close to the mainland (the most distant is

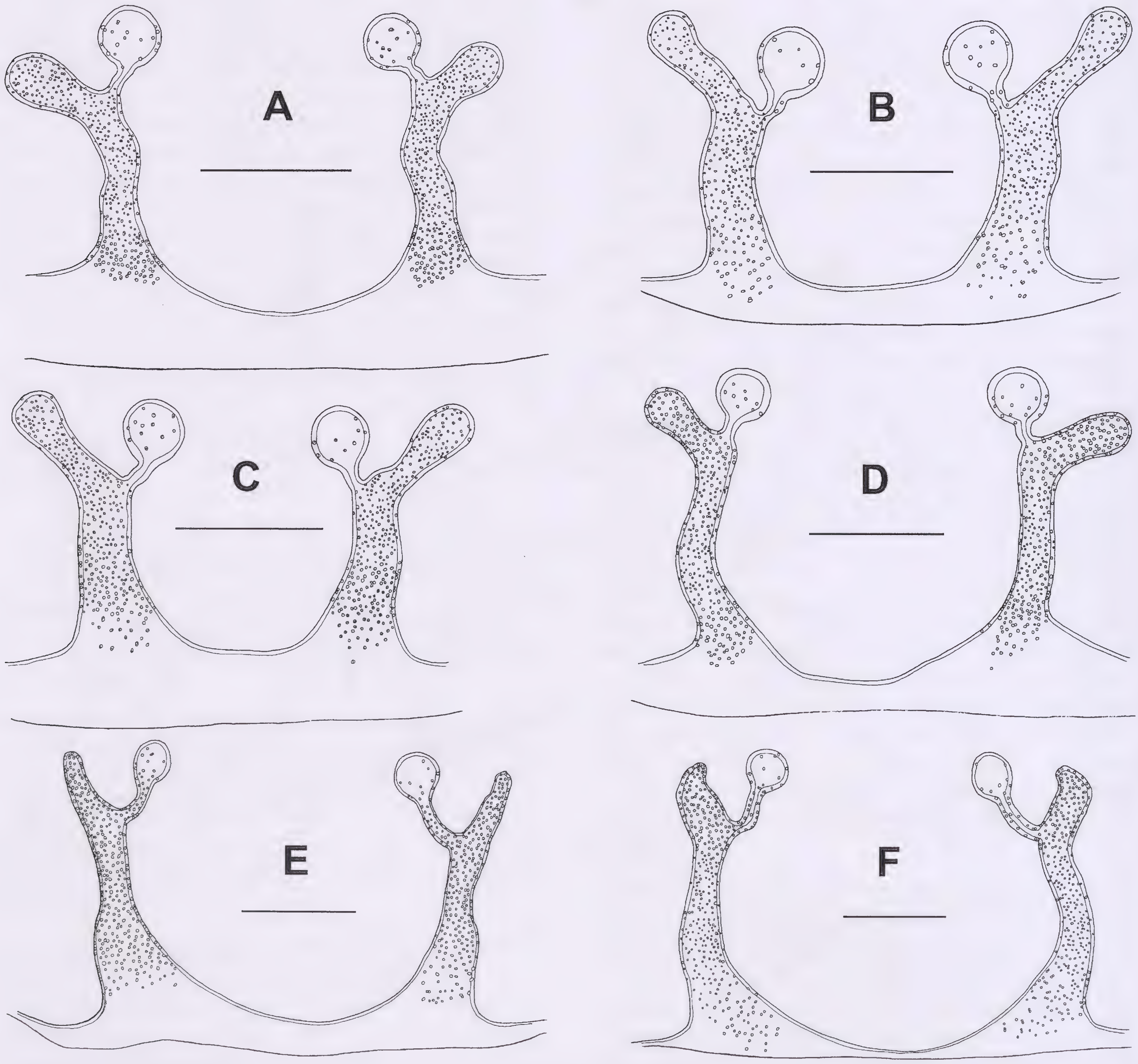


Fig. 4. *Leptothele bencha*; vulvae of six females, dorsal view. (A) Female from Ko Libong. (B-C) Two females from Ko Tarutao. (D) Female from Ko Lanta. (E-F) Two females from Ko Siray. Scale lines 0.1 mm.

Ko Tarutao, about 17 km offshore, Fig. 2, locality 10). Despite extensive sieving of forest litter on Phuket Island and at numerous additional forest sites in southern Thailand, no other conspecific specimens were collected.

Biology: Most spiders examined were collected by sieving leaf litter in semi-evergreen rain forests. At Thab Khaek - Hang Nak Hill they were found in tiny tunnel webs in holes of earthbanks on roadside and in holes and in moss on granite rock close to a small waterfall in the forest. This species does not have a clear preference for limestone (as *Phyxioschema* spp. in southern Thailand have): only at Ban Chong Phlie was a female collected from a web in a crack of a limestone bolder. Four females from Ko Libong produced egg sacs in captivity in late August 2005; from one of them spiderlings hatched 22 days later. In captivity – but not in nature – females from Ko Libong and Ko Tarutao camouflaged the white lenticular egg sacs by attaching soil particles to their surface. No limited mating period could be observed. Some males from the northern localities were collected as adults in the field between late June and early December, others collected as immatures matured in captivity during the same period of the year. On Ko Sukon a mature male was collected in late May, and males collected on Ko Tarutao in early January matured in February and between June and November.

In captivity a pair from Ko Tarutao mated in the following manner: The male courted in the web of the female by quivering and tiptoeing. He approached the female directly, abruptly and forcefully pulled her towards him, locked his tibia II spur and megaspines onto her femur II which was bent sideward at a right angle, whilst his legs I bent her legs I and palps far backwards. In this locked position, which lasted for 21 minutes, the male alternately inserted his palpal organs several times. The pair then separated abruptly and the female chased the male away. That female produced a first egg sac exactly one month later and the spiderlings hatched two weeks afterwards. A second egg sac was produced later. Another female (collected gravid) from Ko Tarutao constructed seven egg sacs in a succession. A total of 33 egg sacs were preserved, each containing 5-17 eggs and early instar spiderlings; eight eggs was the most common count (n = 7).

Leptothele chang Schwendinger, sp. nov.

Figs 1G-H, K, 5-7

Holotype: MHNG (sample THMA-00/08); male (matured 24.I.2001); THAILAND, Trang Province, Nayong District, Tham Khao Chang Hai, 7°35'24"N, 99°40'05"E, 50 m; 1. & 5.VIII.2000; leg. P.J. Schwendinger.

Paratypes: MHNG; 3 males (matured 13.I., 8.II., 10.IX.2001) and 13 females (allotype moulted 17.I.2001); same collecting data as for holotype. – THNHM; 1 male (matured 2.IV.2001) and 1 female; same collecting data as for holotype.

Etymology: Thai: chang (pronounced with a high tone and a long "a") = elephant. The epithet refers to the type locality, the Tham Khao Chang Hai (= cave of the mountain in which an elephant vanished) and to the size of the new species: it is the larger one of the two known *Leptothele* species. In colloquial Thai a big or tall person is often referred to as "tua chang" = with the body of an elephant.

Diagnosis: Distinguished from *L. bencha* by larger size and paler body colouration. Males with longer bulbous part of palpal organ (Fig. 6A-E cf. Fig. 3A, D, G; H being an exception), with 2-3 ventral megaspines on tibia II (Fig. 6G-K; in *L. bencha* normally two, Fig. 3B-C, E-F, four being an exception, Fig. 3I-J), with wrinkles in front and behind subdistal-ventral ridge on tibia II (Fig. 6H-K; wrinkles absent in *L. bencha*), and with a less pronounced, lower and basally wider ventral process on metatarsus II (Fig. 6G cf. Fig. 3B, E, I). Females with relatively shorter and wider spermathecae, median receptacles with very long and thin stalks (Fig. 7 cf. Fig. 4).

Description: MALE (holotype). Colour in alcohol (slightly darker in life) mostly light brown; sternum, opisthosoma and ventral side of body and limbs slightly lighter; prolateral zone of palpal coxae and all membranes cream-coloured; eye mound black (Fig. 5A-B).

Body 6.70 long. Carapace 2.58 long, 2.30 wide, oval, almost flat, thoracic part slightly higher than cephalic part, quite densely covered with fine, slightly wavy hairs, longest and strongest ones on posterior margin; a few bristles in front of eye mound; two long bristles in front of pitlike fovea.

Eyes on low mound; eye group 0.26 long, anterior eye row slightly procurved, 0.45 wide, posterior eye row slightly recurved, 0.48 wide. Eye diameters and interdistances: AME 0.09, ALE 0.17, PME 0.10, PLE 0.11; AME-AME 0.02, PME-PME 0.13. MOQ 0.20 long, 0.20 wide anteriorly, 0.35 posteriorly.

Chelicerae weak, without intercheliceral tumescence, each groove with 10 teeth on promargin and a short row of tiny medioproximal denticles. Palpal coxae 0.65 long, 0.35 wide; anterior lobe indistinct, with serrula composed of a band of denticles (see Fig. 1K showing female paratype); no cuspules. Labium 0.15 long, 0.50 wide, without cuspules; anterior edge distinctly setose, followed by pallid zone without setae; posterior part pigmented, with few short setae. Sternum 1.30 long, 1.20 wide, cordate; labiosternal suture fused with anterior pair of sigilla, three pairs of free sigilla indistinct and marginal.

Palps (Fig. 6C-E): Measurements: total length 3.75 (1.35 + 0.90 + 0.90 + 0.60). Several long strong bristles dorsally and ventrally on all articles, especially on femur and tibia; tarsus with two dorsodistal spines, plus one weak spine (or strong bristle) on each side disto-laterally. Trichobothria: 6+7 in two rows on tibiae, 8 in an irregular row on tarsi. Palpal organ with a narrow kidney-shaped subtegulum, a much longer and wider, asymmetrically pyriform tegulum, and a quite long (about as long as tegulum), thin embolus tapering to a slightly curved tip. Legs 2134. Leg I 8.80 long (2.45 + 1.30 + 1.90 + 1.90 + 1.25); leg II 8.18 long (2.35 + 1.20 + 1.53 + 1.80 + 1.30); leg III 8.85 long (2.30 + 1.10 + 1.80 + 2.25 + 1.40); leg IV 11.13 long (2.85 + 1.25 + 2.50 + 2.98 + 1.55). All tarsi evenly deep for entire length (not bulged on ventral side), not pseudosegmented and without spines (Fig. 5H); with a few scopuliform hairs (see Fig. 10C-E for *Malayathele cameronensis* sp. nov.) in distal portion,

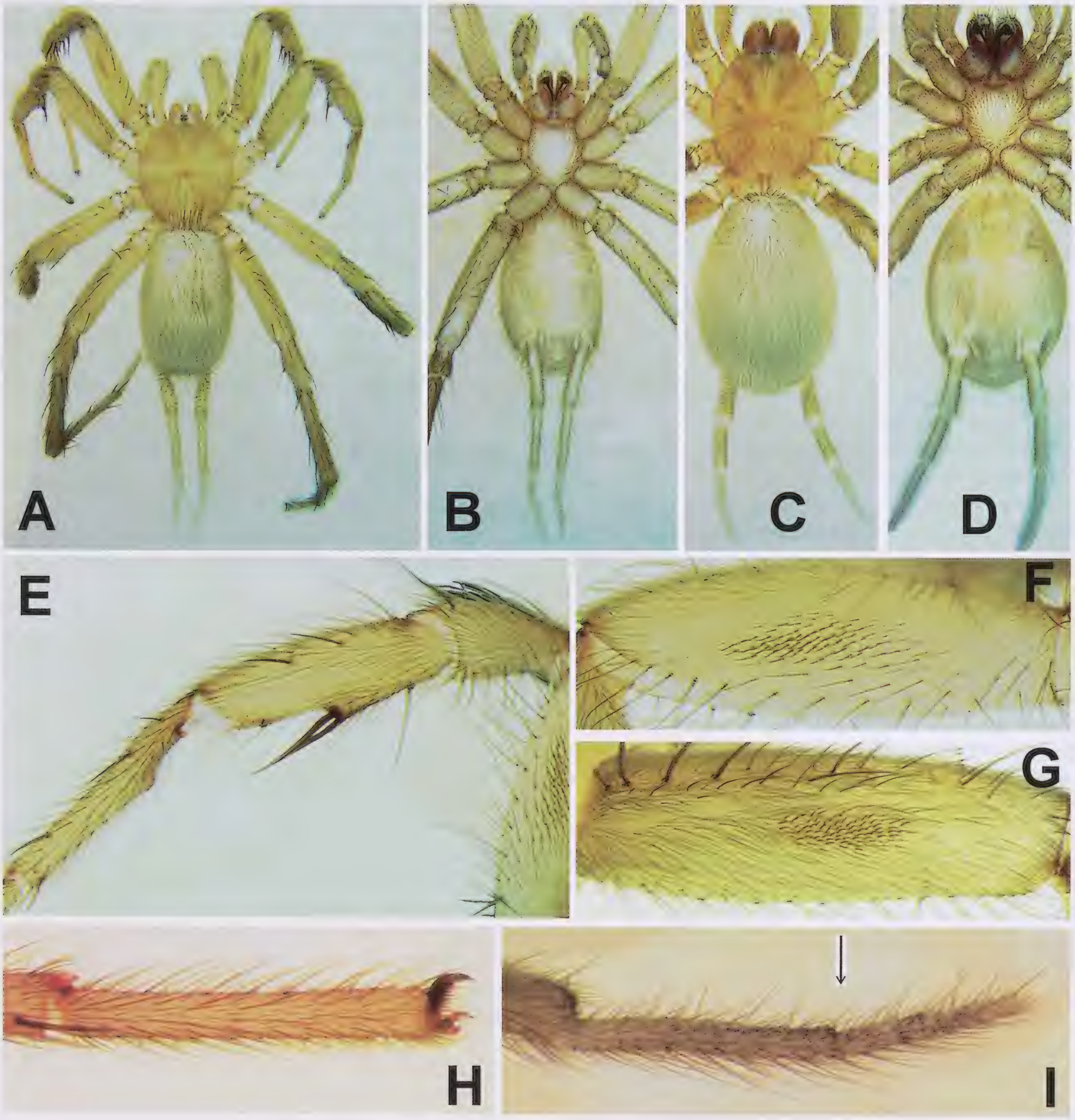


Fig. 5. *Leptothele chang* sp. nov.; male holotype (A-B, E-H), female allotype (C-D) and male paratype (I). (A, C) Habitus, dorsal view. (B, D) Habitus, ventral view. (E) Femur to metatarsus of right leg II, prolateral view. (F) Right femur II, proventral view. (G) Right femur I, retrodorsal view. (H) Tarsus I, lateral view. (I) Distal part of median article and entire distal article of PLS, lateral view; arrow indicating pseudosegmentation. Not to scale.

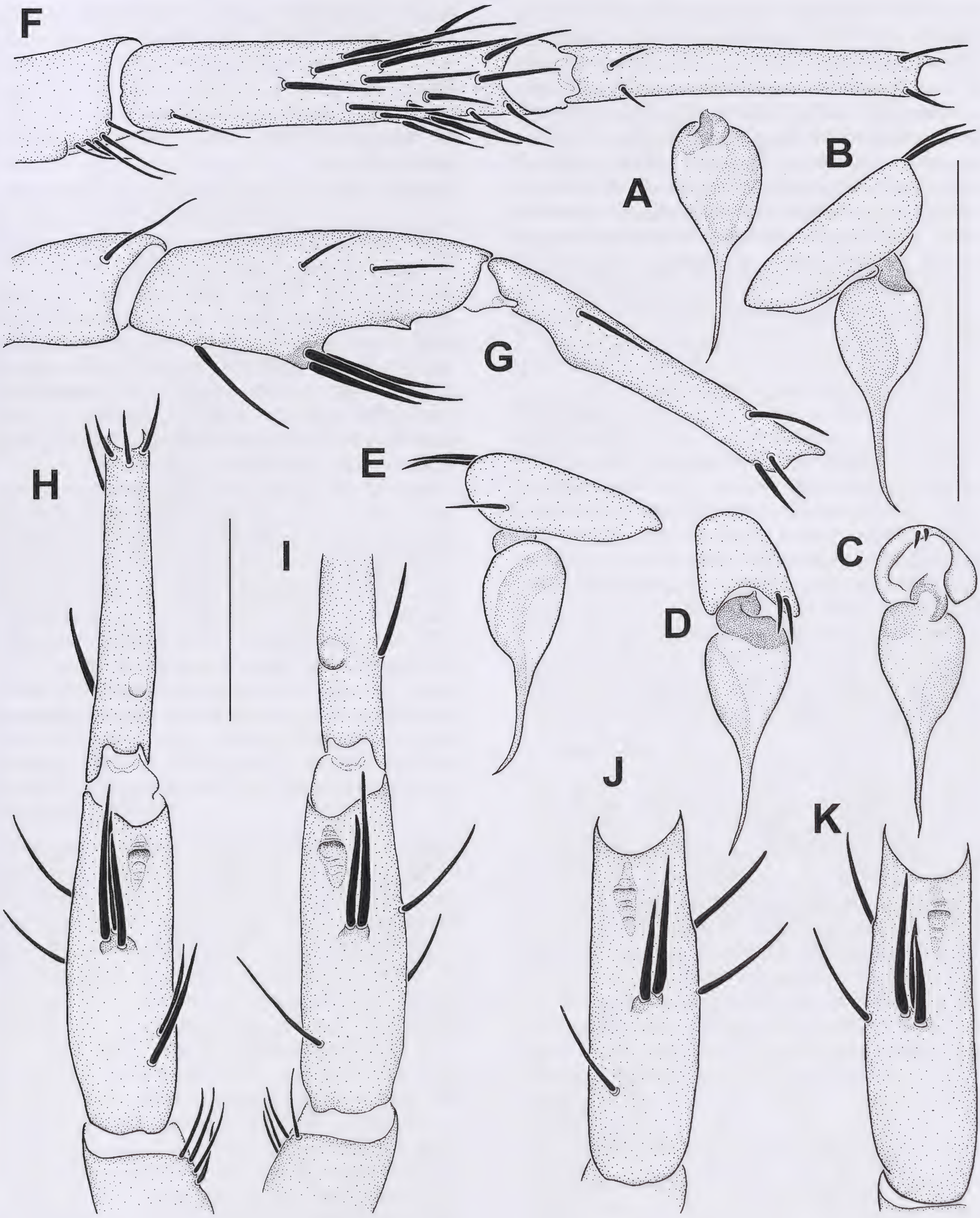


Fig. 6. *Leptothele chang* sp. nov.; male paratype (A-B, J-K) and male holotype (C-I). (A) Right palpal organ, ventral view. (B) Left palpal organ and palpal tarsus, prolateral view. (C) Right palpal organ and palpal tarsus, ventral view. (D) Left palpal organ and palpal tarsus, ventral view. (E) Right palpal organ and palpal tarsus, prolateral view. (F) Patella to metatarsus of left leg I, ventral view. (G) Patella to metatarsus of left leg II, prolateral view. (H) Same, ventral view. (I) Same of right leg II, ventral view. (J) Right tibia II, ventral view. (K) Left tibia II, ventral view. Scale lines 1.0 mm (A-E; F-K).

on anterior tarsi more distinct than on posterior tarsi. Metatarsal preening combs absent. Leg I: Metatarsus with 1/2 proximoventral spines and 2 distoventral spines; tibia not incrassate, not ventrally flattened, carrying 1 prolateral spine and 14/16 ventral spines; patella with a row of bristles retroventrally-distally (Fig. 6F); femur in median third with a short band of hooked spinules retrodorsally (Fig. 5G). Leg II: Ventral side of metatarsus with a low, basally wide, mound-like process in proximal third (Figs 5E, 6G-I). Tibia slightly incrassate, without band of elongate spinules on prolateral side (Figs 5E, 6G); ventral spur low, carrying 2/3 megaspines; low, sharp transversal ridge subdistally on ventral side of tibia lying in a lanceolate area covered by wrinkles (Fig. 6G-I). Band of hooked spinules proventrally on femur short, distant from distal margin of leg article (Fig. 5F).

Spines, trichobothria and claws of legs. All femora with numerous long strong bristles dorsally; I: patella d1; tibia p1, v14/16; metatarsus v3/4. II: patella d1; tibia p2, v2/3 (megaspines); metatarsus p2, v3. III: patella d3; tibia d2, p2, r1/2, v6; metatarsus d6, v6. IV: patella d3; tibia d1, p2, r2, v5/6; metatarsus d7/8, v5/7. Trichobothria: 7+7 in two rows on tibiae, 12 in a single row on metatarsi, 8 in a single row on tarsi. Paired tarsal claws with 11-14 teeth in one row on anterior legs, 9-11 on posterior legs; unpaired claw with 6 teeth on legs I-III, 5 on leg IV.

Opisthosoma 3.45 long, 2.25 wide; densely covered with fine adpressed grey hairs interspersed with longer brown bristles (longest on anterior margin). PMS 0.50 long, 0.10 wide in the middle, separated from each other by 0.90; PLS 3.65 long (proximal article 1.10 long and 0.30 wide, median article 1.15 long and 0.20 wide, distal article 1.4 long and 0.13 wide in the middle), separated from each other by 0.68. Distal article of PLS with a pseudosegmentation at mid-point (see Fig. 5I showing male paratype).

FEMALE (allotype). Colour in alcohol (slightly darker in life) mostly light reddish brown; chelicerae distinctly darker, opisthosoma and ventral side of body and limbs (especially sternum) lighter (Fig. 5C-D).

Body 9.63 long. Carapace 3.54 long, 3.07 wide, oval, almost flat, thoracic part as high as cephalic part, with hairs as in male. Eye group 0.29 long, anterior eye row slightly procurved, 0.55 wide, posterior eye row slightly recurved, 0.63 wide. Eye diameters and interdistances: AME 0.11, ALE 0.17, PME 0.11, PLE 0.12; AME-AME 0.06, PME-PME 0.24. MOQ 0.23 long, 0.26 wide anteriorly, 0.47 posteriorly.

Chelicerae stronger than in male, each groove with 12/13 teeth on promargin and a short row of 13/14 tiny medioproximal denticles. Palpal coxae 0.96 long, 0.59 wide; anterior lobe indistinct, serrula as in Fig. 1K; no cuspules. Labium 0.22 long, 0.68 wide, without cuspules. Sternum 1.65 long, 1.71 wide, cordate, with distinct labiosternal suture (fused with anterior pair of sigillae) and three free pairs of indistinct marginal sigilla.

Palps 5.81 long (1.89 + 1.09 + 1.40 + 1.43). Spination: several long strong bristles dorsally and ventrally on all

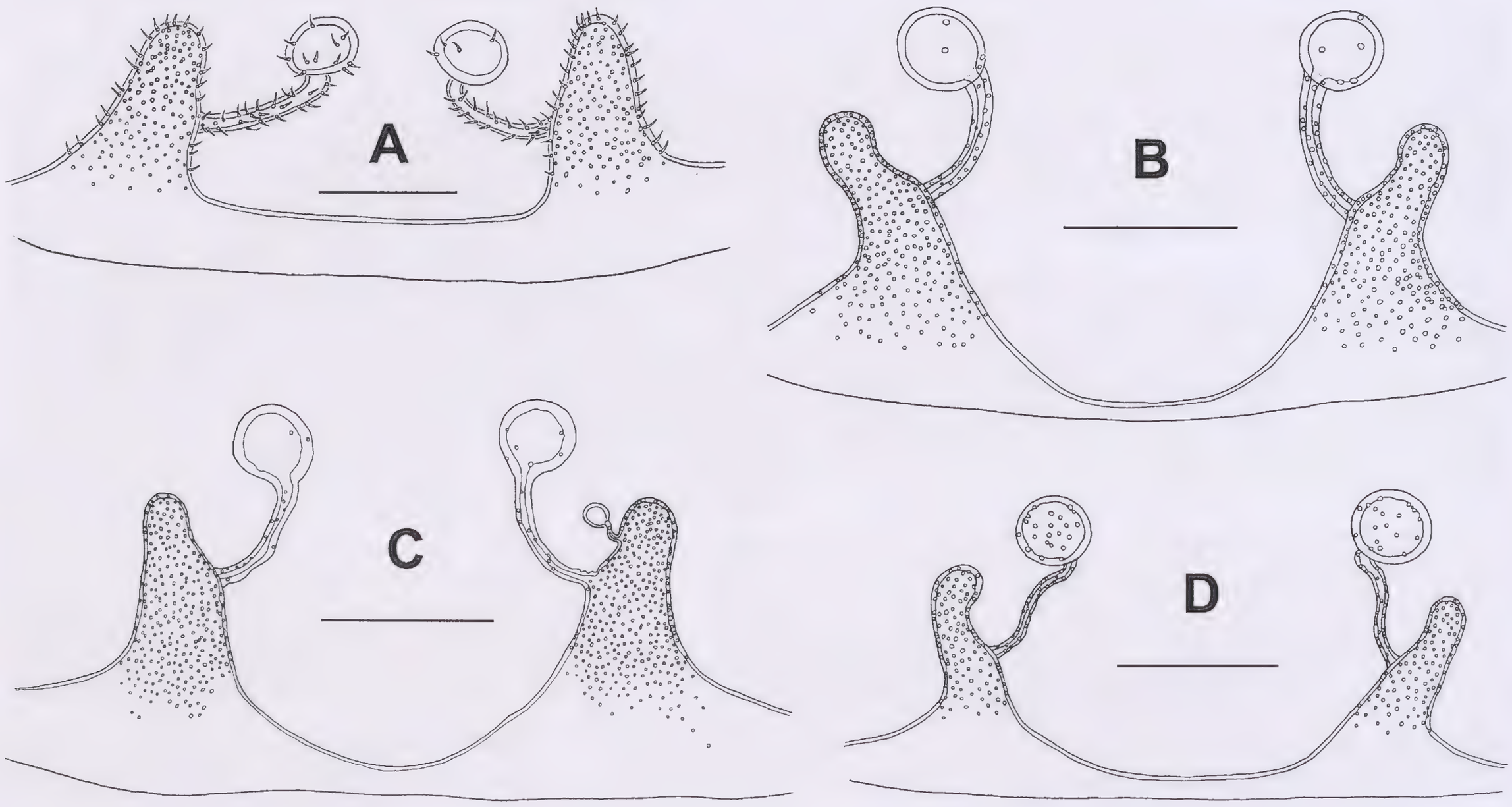


Fig. 7. *Leptothele chang* sp. nov.; vulvae of female allotype (A) and of three female paratypes (B-D), dorsal view. (A) Drawn from exuvia of allotype; cuticular gland duct bases visible. (B-D) Drawn from dissected paratypes; gland duct bases not visible but gland pores instead. (C) Right lateral receptacle carrying a tiny secondary receptacle. Scale lines 0.1 mm.

articles, especially on femur and tibia; tarsus with 8/9 spines ventrally. Trichobothria: 6/7+6/7 in two rows on tibiae, 8 in an irregular row on tarsi.
Legs 2134. Leg I 9.28 long (2.67 + 1.52 + 1.99 + 1.89 + 1.21); leg II 8.94 long (2.55 + 1.43 + 1.86 + 1.89 + 1.21); leg III 9.58 long (2.55 + 1.40 + 1.93 + 2.33 + 1.37); leg IV 11.73 long (3.04 + 1.55 + 2.61 + 2.98 + 1.55). Tarsi without spines and without discernible scopuliform hairs. Metatarsal preening combs absent.
Spines, trichobothria and claws of legs. All femora with numerous long strong bristles dorsally; I: patella d2; tibia p3, v4/6; metatarsus v6. II: patella d2; tibia p3, v5/6; metatarsus p2, v5/6. III: patella d3; tibia d2, p2/3, r2/3, v5/6; metatarsus d5, p1/2, r1/2, v6. IV: patella d3; tibia d2/3, p2, r3, v5/6; metatarsus d5, p2, r1/2, v6. Trichobothria: 7-8+7-8 in two rows on tibiae; 13-16 in one row on metatarsi; 8-9 in one row on tarsi. Paired tarsal claws with 12-15 teeth in a row on anterior legs, 10-12 on posterior legs; unpaired claw with 6 teeth on anterior legs, 5 on posteriors (see Fig. 1G-H showing female paratype).
Opisthosoma 5.40 long, 3.76 wide, with hairs as in male. PMS 0.68 long, 0.19 wide in the middle, separated from each other by 1.18; PLS 5.49 long (proximal article 1.77 long and 0.43 wide, median article 1.55 long and 0.34 wide, distal article 2.17 long and 0.22 wide in the middle), separated from each other by 1.43. Distal article of PLS with a pseudosegmentation at mid-point.
Spermathecae medium-long and moderately wide; lateral receptacles with narrowly rounded heads and no stalks; median receptacles with globular heads and very long (about twice as long as heads) and thin stalks, their walls not sclerotised (Fig. 7A).

Variation: Carapace lengths in males (n = 5) range 2.30-2.73, carapace width 2.03-2.43. In the largest female the carapace length is 3.57, the carapace width 3.10; the smallest reproductive female (constructed three egg sacs) has a carapace length of 2.48 and a carapace width of 2.26. Two males (including the holotype) have three ventral megaspines on the left tibia II and two megaspines on the right tibia II; the other three males have two megaspines on both tibiae II. Variation in the number of ventral megaspines (two probably being more common than three) on tibia II in this species appears to be much greater than in *L. bencha* (only a single, asymmetrical case among 24 specimens examined, and that is a very unusual tibia II with a very low ventral spur carrying four megaspines). A similar tibia II megaspine variation is known from *Phyxioschema suthepium* (45 males with 2+2, 2 with 2+3, 1 with 3+3; n = 48), *P. huberi* (5 males with 2+2, 3 with 3+3, 1 with 3+4, 1 with 4+5; n = 10) and *P. eripnastes* (3 males with 2+2, 1 with 2+3; n = 4) (Schwendinger, 2009). There are 11-16 ventral and 1-2 prolateral spines on tibia I, and metatarsus I has mostly two (on one leg three) distal spines, 0-2 median spines and 1-2 proximal spines. One male paratype has three dorsodistal spines (two strong, one weak) on both palpal tarsi, all other males have only two such spines. Variation in the shape of the vulva of four females is shown in Fig. 7. The allotype has lateral receptacles without recognizable stalks (Fig. 7A), whereas in the other females the stalks are more or less constricted (Fig. 7B-D). One of the females examined has a tiny secondary receptacle situated anterior of the median receptacle on one of its spermathecae (Fig. 7C).

Distribution and habitat: *Leptothele chang* sp. nov. is only known from its type locality in southern Thailand (Fig. 2, locality 11). Unlike the closely related *L. bencha*, the new species occurs quite far away from the coast, at the entrance of a limestone cave, but seemingly not in the dark parts of the cave or in the surroundings of the cave.

Biology: The type specimens were all collected from irregular tunnel webs spun between discarded wooden poles in the oligophotic zone and in holes and cracks in dry soil at the entrance of a limestone cave. When collected at the beginning of August, one female had a hemispherical egg sac (containing 28 eggs) suspended in the aerial portion of its web. Another female built an egg sac in captivity at the beginning of October of the same year. Six preserved egg sacs, four of them resulting from mating in captivity during the following year, contain 14-44 eggs and early instar spiderlings. These egg sacs were built 20-24 days after mating (4 observations). Females built up to three egg sacs and moulted three times per year. Males matured in captivity in January, February, April and November. There appears to be no limited mating period. Mating was performed as described for *L. bencha* in this text, with the tibia II coupling spurs and megaspines of the male locking onto femora II of the female and pushing them to the side. Then he very abruptly and forcefully pulled her towards him whilst bending her prosoma and anterior limbs backwards into the mating position. The first act of mating lasted only three minutes, but was repeated three times consecutively. The second copula of the same male, but with another female, was performed only once and it lasted for 20 minutes.

Malayathele Schwendinger, gen. nov.

Etymology: "Malaya" is one of the old names for Malaysia, the only county from where the new spider genus is known with certainty; "thele" (Greek for "nipple"; figurative for nipple-shaped or wart-shaped structures), refers to the long posterior lateral spinnerets of these spiders and to the close relationship with the genus *Leptothele*.

Type species: *Malayathele kanching* sp. nov., by present designation.

Diagnosis: Distinguished from *Phyxioschema* by characters given in the key to Euagridae genera of Asia, most prominently by small body size in both sexes, and by tibia II of males without elongate spinules on prolateral side (Figs 10B, 12G) and with only a single megaspine on a low ventromedian spur (Figs 8H-K, 10B, 11G-J, 12G, 13J-M, 15F-H). Distinguished from *Leptothele* by metatarsal preening combs present on legs II-IV in both sexes. Males with only one megaspine and no transversal subdistal ridge on ventral side of tibia II, and mostly with two small conical processes (a retroventral and a proventral one, Figs 12G, 13J-M, 15F-H; the proventral one absent in *M. ulu* sp. nov., Fig. 8I-J, the retroventral one keel-shaped in *M. cameronensis* sp. nov., Figs 10B, 11G-J) on metatarsus II; tarsi I-II ventrally bulged (Fig. 10D). Females distinguished by possessing median receptacular stalks with sclerotised walls (Figs 9, 11K, 14, 16).

Description: Body very small (carapace length in males 1.11-1.44), with relatively thin hair cover on carapace, no colour pattern (Fig. 12E-F, H-I) or a dark mottled pattern on hirsute opisthosoma (Fig. 12A-D). Fovea pitlike, with a pair of long straight bristles anterior of it (Fig. 12A, C, E, H). Eye group distinctly wider than long, anterior eye row slightly or not procurved, posterior eye row moderately or slightly recurved. Clypeus present, shorter than eye group length (Fig. 12A, C, E, H).

Chelicerae small, without rastellum, with teeth only on promargin of groove; intercheliceral tumescence absent. Palpal coxae rectangular, quite wide and posteriorly arched, with a bulging ventral surface, its prolateral zone glabrous and lightly pigmented; no cuspules present (Fig. 12B, F, I); anterior lobe indistinct, carrying a serrula formed by a narrow band of tiny denticles (Fig. 1L). Labium much wider than long, without cuspules; anterior edge carrying a row of bristles followed by a pallid zone without setae; posterior part pigmented, with few short setae. Sternum cordate; post-labial sigilla medially fused with quite long labiosternal suture; remaining three pairs of sigilla indiscernible.

Legs moderately long and thin, with spines on patellae to metatarsi; all tarsi aspinose and not pseudosegmented; tarsi I-II of males more or less distinctly bulged on ventral side and carrying a few scopuliform hairs (Fig. 10C-E); metatarsi II-IV of both sexes with preening combs; filiform trichobothria in two dorsal rows on tibiae, and in one row on metatarsi and tarsi; tarsal organ inconspicuous, cowpad-shaped, quite remote from distal margin of tarsus. Leg I of males with only two (Fig. 11E-F) or 6-7 (Figs 8F-G, 13H-I, 15D-E) ventral spines on cylindrical, not incrassate tibia; patella with a series of bristles (Figs 8F, 10A, 11F, 13I) or with a single spine (Fig. 15E) retroventrally-distally. Leg II of males with a small conical proventral process and a small conical retroventral processes (Figs 12G, 13J-K, M, 15F-H), or with only a small conical retroventral process (Fig. 8I-J), or with a small conical proventral process and a longer keel-shaped retroventral process (Figs 10B, 11G-J) on metatarsus; tibia with a single, slightly curved or slightly sigmoid megaspine on a low medioventral spur; area

Key to the species of *Malayathele* gen. nov.:

1A Males with corkscrew-shaped embolus (Fig. 11A-D), with only two ventral spines on metatarsus I (Figs 10A, 11E-F) and with retroventral process on metatarsus II developed as a short blunt keel (Fig. 11G-J). Females with very wide, quite short spermathecal trunks bearing rudimentary (reduced to a boss) lateral receptacles (Fig. 11K) ..... *M. cameronensis* sp. nov.

1B Males with more or less strongly curved embolus (Figs 8A-E, 13A-G, 15A-C), with 6-7 ventral spines on metatarsus I (Figs 8F-G, 13H-I, 15D-E) and with retroventral process on metatarsus II developed as a small cone (Figs 8H-K, 13J-M, 15F-H). Females with narrower spermathecal trunks and with well-developed lateral receptacles (Figs 9, 14, 16) 2

2A Males with only slightly curved embolus (Fig. 8A-E) and with only one ventral process (the retroventral one) on metatarsus II (Fig. 8H-K). Females without dark pattern on opisthosoma; stalks of median receptacles longer than corresponding heads (Fig. 9) ..... *M. ulu* sp. nov.

2B Males with slightly or strongly curved embolus (Figs 13A-G, 15A-C) and with two ventral processes on metatarsus II (Figs 12G, 13J-M, 15F-H). Females with more or less distinct dark pattern on opisthosoma (Fig. 12A-D); stalks of median receptacles as long as or shorter than corresponding heads (Figs 14, 16) 3

3A Males with distally strongly curved embolus (Fig. 15A-C); patella I retroventrally-distally with a single spine (Fig. 15E). Females with dark pattern of opisthosoma indistinct and restricted to dorsal side; spermathecal trunks rectangular, lateral receptacles bent ventrad, their stalks not constricted (Fig. 16) ..... *M. kanching* sp. nov.

3B Males with only slightly curved embolus (Fig. 13A-G); patella I retroventrally-distally with a series of bristles (Fig. 13I). Females with dark pattern of opisthosoma distinct and extending to posteroventral side (Fig. 12A-D); spermathecal trunks conical, lateral receptacles directed anteriad, their stalks clearly constricted (Fig. 14) ..... *M. maculosa* sp. nov.

between ventral spur and distoventral margin of tibia slightly flattened and wrinkled (Figs 8H-K, 10B, 11H-J, 12G, 13J-M; indistinct wrinkles in *M. kanching* sp. nov., Fig. 15F-H). Paired leg claws with a single row of 4-12 teeth; unpaired claws with 1-3 quite long teeth, the basal ones on posterior legs set on a common base (Figs 1I-J, 10C).

Palpal tarsus of males with two apical lobes, the retrodorsal lobe larger than the prodorsal one and carrying 2-3 distal spines (as in *Leptothele*); palpal organ with short lenticular subtegulum and wide bulbous tegular part, embolic part thin and apically pointed, either slightly curved (Figs 8A-E, 13A-G), strongly curved (Fig. 15A-C) or corkscrew-shaped (Fig. 11A-D).

Four widely separated spinnerets; no australotheline crescent at base of PLS; PMS short and with only one article; PLS long and composed of three articles (Fig. 12B, D, E-F, H-I); distal article of PLS not pseudosegmented, with a reduced pigmentation in posterior half (Fig. 12J-K).

Vulva with two spermathecae, each carrying two receptacles; lateral receptacles anteriad-directed (Figs 9, 11K, 14) or ventrad-directed (Fig. 16), perforated by numerous gland pores for their entire length, with more or less distinctly constricted, unsclerotised stalks (Figs 9, 14), without discernible stalks (Fig. 16) or altogether strongly reduced (Fig. 11K); median receptacles always clearly separated into a more or less strongly curved or twisted stalk with sclerotised walls and a bulbous or globular head perforated by few or no pores (Figs 9, 11K, 14, 16).

Species and distribution: *Malayathele cameronensis* sp. nov., *M. kanching* sp. nov., *M. maculosa* sp. nov. and *M. ulu* sp. nov., all from the Titiwangsa Mountain Range (= Main Range, Banjaran Besar) of Peninsular Malaysia and its foothills (Fig. 2, localities 12-18). At least one undescribed species in the northeastern part of the country (Fig. 2, locality 19).

Malayathele ulu Schwendinger, sp. nov.

Figs 1I-J, 8-9

Holotype: MHNG (sample SIM-01/14); male; MALAYSIA, Perak, E of Gopeng, Ulu Groh (= Geroh), 4°26'50"N, 101°16'07"E, rain forest, 500 m; 21.I.1994; leg. P.J. Schwendinger.

Paratypes: MHNG; 5 females; same collecting data as for holotype. – MHNG; 1 male, 3 females; MALAYSIA, Pahang, Cameron Highlands, Tanah Rata, 4°28.4-28.7'N, 101°21.6-22.1'E, 1470-1550 m; 25.IV.-15.V.2009; leg. P. Banar. – MHNG (sample WM93-15); 1 female; Pahang, Cameron Highlands, trails 4 and 13; 23.III.1993; leg. I. Löbl & F. Calame. – MHNG; 7 females; Pahang, Cameron Highlands, Orang Asli village near Gunung Perdah, 4°29.2'N, 101°22.1'E, 1575 m; 2.-14.V.2009; leg. P. Banar. – MHNG; 4 females, 5 juveniles; Pahang, Cameron Highlands, near Tanah Rata, Parit Falls, 4°28.5'N, 101°23'E, about 1500 m; 26.IV.2009; leg. P. Banar. – MHNG; 1 female; Pahang, Cameron Highlands, Tanah Rata, 4300 feet; 7.VIII.1972; leg. T. Jaccoud. – MHNG (sample I 82); 1 female; Pahang, Cameron Highlands, Tanah Rata; 24.III.1977; leg. T. Jaccoud & P. Marcuard.

Other material: MHNG; 3 juveniles; MALAYSIA, Perak, Gopeng, Ulu Groh, 4°26'50"N, 101°16'07"E, 500 m; 21.I.1994; leg. P.J. Schwendinger. – MHNG; 3 juveniles; Pahang, Cameron Highlands, Tanah Rata, 4°28.4-28.7'N, 101°21.6-22.1'E, 1470-1550 m; 25.IV.-15.V.2009; leg. P. Banar.

Etymology: The species epithet (derived from "hulu") is a Malay noun that means "upriver" and usually refers to a remote, undeveloped area. It is a reference to the type locality.

Diagnosis: Males distinguished from those of the other three congeneric species by the absence of a proventral process on metatarsus II (Fig. 8H-K), from that of *M. cameronensis* sp. nov. (which occurs in the same area) additionally by numerous (6-7 instead of only two) ventral spines on tibia I (Fig. 8F-G cf. Fig. 11E-F) and by a small conical retroventral process (instead of a keel-shaped one) on metatarsus II (Fig. 8H-K); additionally distinguished from males of *M. kanching* sp. nov. by a series of bristles (instead of a single spine) retroventrally-distally on patella I (Fig. 8F cf. Fig. 15E). Females distinguished from those of all other congeners by possessing median receptacles with long stalks (distinctly longer than corresponding heads; Fig. 9).

Description: MALE (holotype). Colour in alcohol (slightly darker in life) mostly very light brown; palpal organ and cheliceral claws darker; eye mound black; no dark pattern on opisthosoma.

Body 3.06 long. Carapace 1.29 long, 1.03 wide, oval, thoracic part slightly higher than cephalic part, sparsely covered with fine wavy hairs, a few stronger ones in front of eye mound and between eye mound and fovea; two long bristles in front of pitlike fovea. Eyes on low mound; eye group 0.13 long, anterior eye row slightly procurved, 0.21 wide, posterior eye row moderately recurved, 0.22 wide. Eye diameters and interdistances: AME 0.04, ALE 0.07, PME 0.06, PLE 0.07; AME-AME 0.02, PME-PME 0.02. MOQ 0.11 long, 0.07 wide anteriorly, 0.13 posteriorly.

Chelicerae weak, grooves with 13/14 teeth on promargin. Palpal coxae 0.33 long, 0.21 wide. Labium 0.13 long, 0.24 wide. Sternum 0.71 long, 0.65 wide.

Palps (Fig. 8C-E). Measurements: total length 1.81 (0.65 + 0.38 + 0.45 + 0.33). Spination: several long strong bristles dorsally and ventrally on all articles, especially on femur and tibia; tarsus with 2 dorsodistal spines, plus one short strong bristle prolaterally-distally and one retrolaterally-distally. Palpal organ with gently curved embolus tapering to a pointed apex.

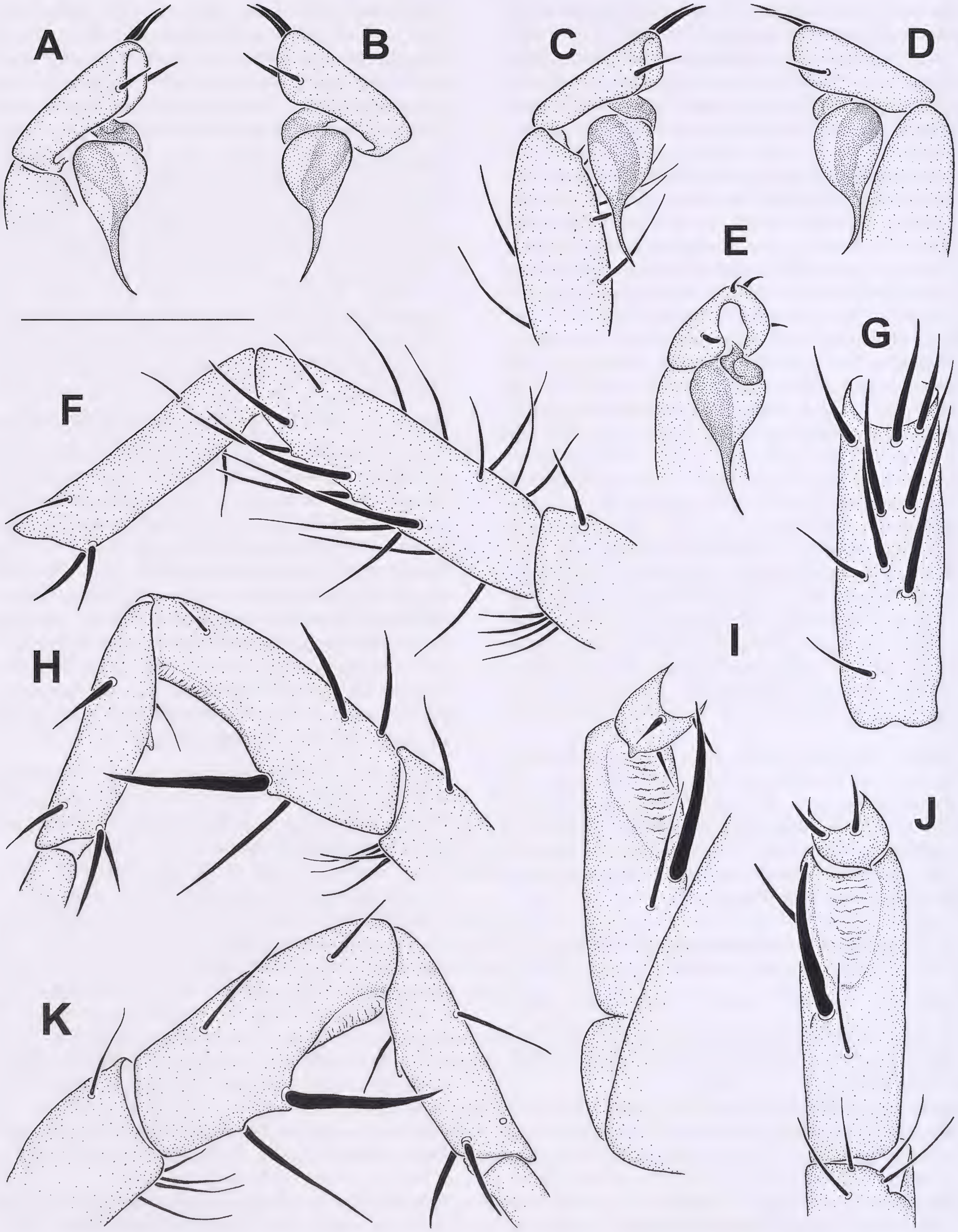


Fig. 8. *Malayathele ulu* sp. nov.; male paratype (A-B, J-K) and male holotype (C-I). (A, C) Distal part of left palp, prolateral view. (B, D) Same of right palp, prolateral view. (E) Distal part of left palp, ventral view. (F) Patella to metatarsus of right leg I, prolateral view. (G) Right tibia I, ventral view. (H) Patella to metatarsus of right leg II, prolateral view. (I) Same, retroventral view. (J) Patella to metatarsus of left leg II, ventral view. (K) Same, prolateral view. Scale line 0.5 mm.

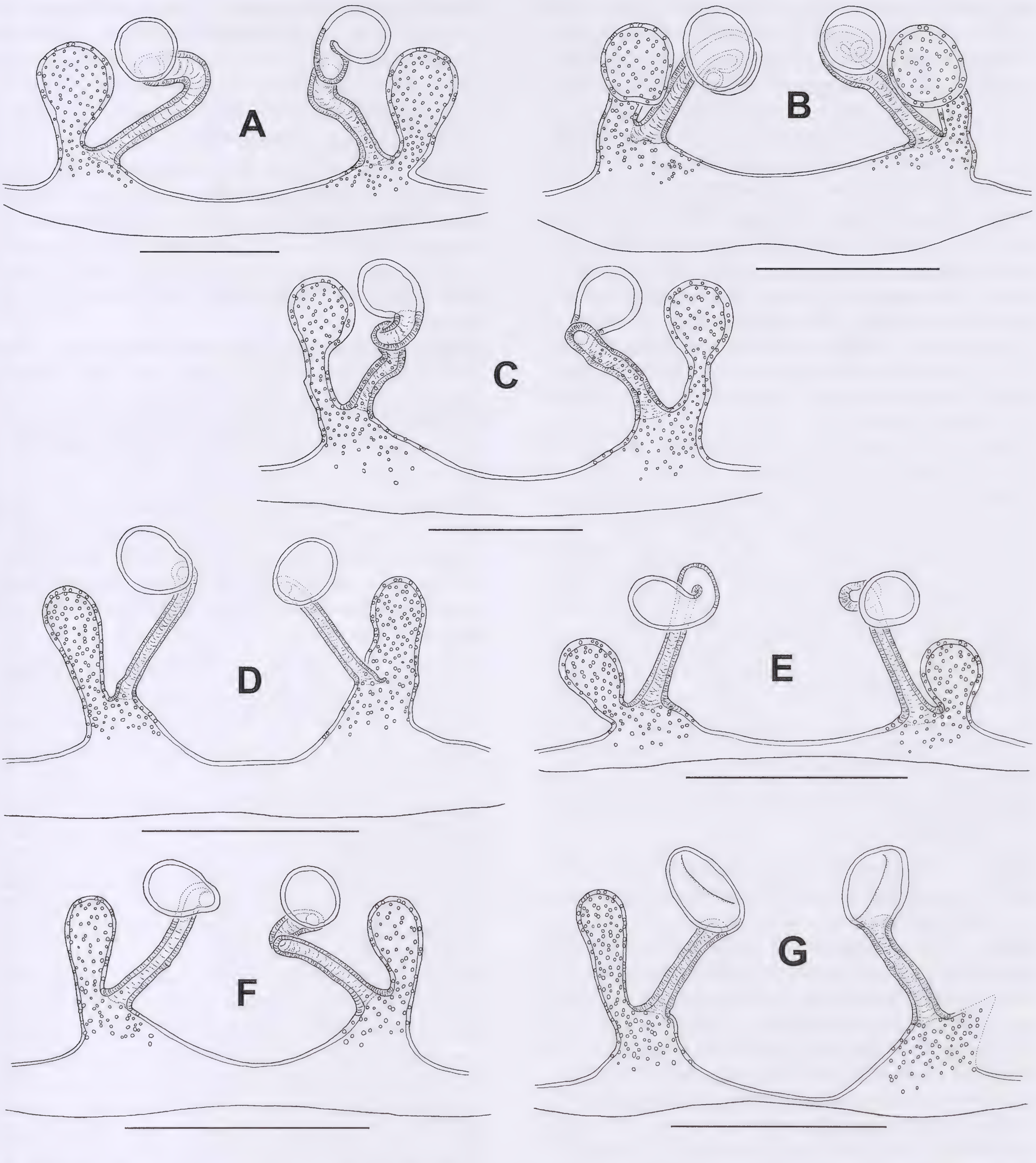


Fig. 9. *Malayathele ulu* sp. nov.; vulvae of seven females (all drawn from dissected specimens), dorsal view. (A) Allotype. (B-C) Paratypes from the type locality (Ulu Groh). (D-G) Paratypes from the Cameron Highlands: Parit Falls, 26.IV.2009 (D); Tanah Rata, 7.VIII.1972 (E); Gunung Perdah, 2.-14.V.2009 (F); trails 4 & 13, 23.III.1993, heads of median receptacles collapsed and right lateral receptacle torn off (G). Scale lines 0.1 mm.

Legs 3214. Leg I 3.42 long (0.98 + 0.60 + 0.70 + 0.63 + 0.51); leg II 3.18 long (0.93 + 0.55 + 0.61 + 0.58 + 0.51); leg III 3.13 long (0.83 + 0.48 + 0.58 + 0.70 + 0.54); leg IV 3.97 long (1.05 + 0.60 + 0.80 + 0.91 + 0.61). Tarsi not pseudosegmented and without spines; with a few scopuliform hairs in distal portion of anterior legs. Metatarsal preening combs on legs II-IV. Leg I: Tibia carrying 7 ventral spines plus 2 strong ventral bristles (Fig. 8G). Femur with quite wide band of hooked spinules retrodorsally. Leg II: Metatarsus with only a small conical retroventral process (Fig. 8H-I). Tibia with a low ventral spur carrying a single megaspine, plus a long strong ventral bristle more proximally; a series of fine transversal wrinkles subdistally on ventral side (Fig. 8H-I). Band of hooked spinules proventrally on femur II longer than corresponding band on femur I, the spinules more widely spaced.

Spines, trichobothria and claws of legs. All femora with numerous long strong bristles dorsally; I: tibia v7; metatarsus v2. II: tibia p2, v1 (megaspine); metatarsus v2. III: patella d1, r1; tibia d2, p2, r2, v5; metatarsus d4, p2, v3. IV: patella d1, r1; tibia d2, p2, r2, v5; metatarsus d5, p2, v4. Trichobothria not counted (difficult to see). Paired tarsal claws with 7-9 teeth on anterior legs, 5-7 on posterior legs; unpaired tarsal claws with 2-3 teeth.

Opisthosoma 1.36 long, 0.83 wide; densely covered with fine adpressed grey hairs interspersed with longer dark bristles (longest on anterior margin). PMS 0.23 long, 0.06 wide in the middle, separated from each other by 0.25. PLS 1.49 long (proximal article 0.49 long and 0.15 wide, median article 0.50 long and 0.13 wide, distal article 0.50 long and 0.10 wide in the middle), separated from each other by 0.45.

FEMALE (allotype). Colour in alcohol (slightly darker in life) as in male but slightly darker; no dark colour pattern on opisthosoma.

Body 4.43 long. Carapace 1.65 long, 1.29 wide. Eye group 0.16 long, anterior eye row slightly procurved, 0.20 wide, posterior eye row moderately recurved, 0.23 wide. Eye diameters and interdistances: AME 0.03, ALE 0.10, PME 0.08, PLE 0.12; AME-AME 0.02, PME-PME 0.04. MOQ 0.11 long, 0.10 wide anteriorly, 0.17 posteriorly.

Chelicerae stronger than in male, grooves with 14/15 teeth on promargin. Palpal coxae 0.44 long, 0.30 wide. Labium 0.11 long, 0.33 wide. Sternum 0.89 long, 0.81 wide.

Palps. Total length 2.36 (0.78 + 0.48 + 0.54 + 0.56). Several long strong bristles dorsally and ventrally on all articles, especially on femur and tibia; tarsus with five distinct ventral spines. Claws with 11 denticles.

Legs 3=214. Leg I 3.73 long (1.11 + 0.67 + 0.76 + 0.66 + 0.53); leg II 3.41 long (1.00 + 0.59 + 0.65 + 0.63 + 0.54); leg III 3.41 long (0.96 + 0.55 + 0.61 + 0.73 + 0.56); leg IV 4.29 long (1.20 + 0.70 + 0.84 + 0.96 + 0.59). Tarsi not pseudosegmented and without spines; without scopuliform hairs. Metatarsal preening combs on legs II-IV.

Spines, trichobothria and claws of legs. All femora with numerous long strong bristles dorsally; I: patella p2 (strong bristles); tibia v4/5 (strong bristles); metatarsus v2 (plus v2 strong bristles). II: patella p2 (strong bristles); tibia p2, v5 (strong bristles); metatarsus p2 (strong bristles), v2 (plus v2 strong bristles). III: patella d1 r1; tibia d2, p2, r2, v4 (plus v1 strong bristle); metatarsus d4, 2p, v5. IV: patella d1 r1; tibia d1, p2, r2, v5 (plus v1 strong bristle); metatarsus d5, p2, v4. Trichobothria not counted (difficult to see). Paired tarsal claws with 10-12 teeth on anterior legs, 8-10 on posterior legs; unpaired tarsal claws with 2-3 teeth (Fig. 1I-J showing different female).

Opisthosoma 2.30 long, 1.60 wide. PMS 0.28 long, 0.07 wide in the middle, separated from each other by 0.45. PLS 1.44 long (proximal article 0.50 long and 0.19 wide, median article 0.44 long and 0.16 wide, distal article 0.50 long and 0.11 wide in the middle), separated from each other by 0.65.

Spermathecae quite narrow; all receptacles with distinct stalks and pyriform heads; median receptacles much longer than lateral ones, their stalks thin and slightly twisted, with sclerotized walls; lateral receptacles with voluminous heads and short stalks, their walls not sclerotised (Fig. 9A).

Variation: Carapace length in males (n = 2) range 1.29-1.39, carapace width 1.03-1.06. Both males have the left leg I missing and carry seven ventral spines on the right tibia I. The largest female (from the type locality) has a 1.75 long and 1.35 wide carapace. In the male holotype the thoracic region of the carapace is slightly higher than the cephalic region, whereas in the male paratype both regions are equally high. For a slight variation in the proportions of the palpal organs see Fig. 8A-E. A stronger variation in the shape of the vulvae is shown in Fig. 9. In females from the Cameron Highlands the median receptacular stalks appear to be mostly straight and the lateral receptacular heads quite narrow (Fig. 9D-G), whereas in females from the type locality the median receptacular stalks are more strongly bent and twisted and the lateral receptacular heads are wider (Fig. 9A-C). These different vulva types are here considered as expressions of a lowland and an upland form, not of different subspecies. No taxonomically relevant differences in the characters of males from both forms were found (Fig. 8).

Distribution: This species occurs in the lowlands at the foot of the Cameron Highlands (Ulu Groh) and at altitudes of about 1500 m near Tanah Rata in the Cameron Highlands (Fig. 2, localities 12 and 14). It very likely also occurs at Chenderiang, a second lowland locality south of Ulu Groh (Fig. 2, locality 13). It would be interesting to investigate if and to what degree the lowland and upland populations are geographically and genetically separated from each other.

Biology: The spiders examined were collected by sieving ground litter in rain forests.

Malayathele cameronensis Schwendinger, sp. nov.

Figs 10-11

Holotype: MHNG; male; MALAYSIA, Pahang, Cameron Highlands, near Tanah Rata, Gunung Jasar, 4°28.4-28.7'N, 101°21.6-22.1'E, 1470-1700 m; 18.IV.-11.V.2009; leg. P. Banar.

Allotype: MHNG; 1 female; same collecting data as for holotype.

Other material: MHNG; 2 juveniles; collected together with the types.

Etymology: The species epithet is a Latinised adjective referring to the type locality of this species.

Diagnosis: Male distinguished from those of the other three congeneric species by the presence of a corkscrew-shaped embolus (Fig. 11A-D) and of a keel-shaped retroventral process on metatarsus II (Fig. 11G-J), tibia I with only two ventral spines (Fig. 11E-F); additionally distinguished from males of *M. ulu* sp. nov. by the presence of two (instead of one) ventral processes on metatarsus II (Fig. 11G-J cf. Fig. 8I-J), and from males of *M. kanching* sp. nov. by a series of bristles (instead of a single spine) retroventrally-distally on patella I (Fig. 11F cf. Fig. 15E). Female distinguished from those of all other congeners by possessing very wide spermathecal trunks with reduced, boss-like lateral receptacles and with strongly convoluted, quite wide and strongly sclerotised stalks of the median receptacles (Fig. 11K); additionally distinguished from females of *M. maculosa* sp. nov. (and to a lesser extent also of *M. kanching* sp. nov.) by the lack of a dark colour pattern on the opisthosoma.

Description: MALE (holotype). Colour in alcohol mostly light brown; sternum and opisthosoma (including spinnerets) lighter; palpal organ and cheliceral claws darker; eye mound black.

Body 3.13 long. Carapace 1.46 long, 1.18 wide, oval, thoracic part equally high as cephalic part; few hairs present (many abraded during sieving from leaf litter), a few stronger ones in front of eye mound and in two paramedian rows behind it; pits of two bristles in front of pitlike fovea. Eyes on low mound; eye group 0.20 long, anterior eye row slightly procurved, 0.29 wide, posterior eye row moderately recurved, 0.32 wide. Eye diameters and interdistances: AME 0.05, ALE 0.14, PME 0.09, PLE 0.11; AME-AME 0.02, PME-PME 0.05. MOQ 0.12 long, 0.10 wide anteriorly, 0.20 posteriorly.

Chelicerae weak, grooves with over 10 teeth on promargin (not all visible). Palpal coxae 0.40 long, 0.26 wide. Labium 0.10 long, 0.29 wide. Sternum 0.84 long, 0.78 wide.

Palps (Fig. 11A-D). Total length 2.05 (0.71 + 0.46 + 0.53 + 0.35). Several long strong bristles dorsally and ventrally on all articles, especially on femur and tibia; tarsus with 2 dorsodistal spines, plus one short and rather indistinct (in comparison with males of other congeners) strong bristle prolaterally-distally and retrolaterally-distally. Palpal organ with corkscrew-shaped embolus.

Legs 3214. Leg I 3.97 long (1.14 + 0.69 + 0.83 + 0.75 + 0.56); leg II 3.51 long (1.05 + 0.63 + 0.65 + 0.68 + 0.50); leg III 3.46 long (0.98 + 0.54 + 0.65 + 0.78 + 0.51); leg IV 4.68 long (1.25 + 0.69 + 0.98 + 1.11 + 0.65). Tarsi not pseudosegmented and without spines; with a few scopuliform hairs in distal portion of anterior legs (Fig. 10C-E). Metatarsal preening combs on legs II-IV. Leg I: Tibia carrying only 2 ventral spines plus 5 strong ventral bristles (Fig. 11E-F; one spine fallen off on left tibia, Fig. 10A). Femur with quite short band of hooked spinules retrodorsally (Fig. 10A). Leg II: Metatarsus with two small ventral processes, the retroventral one a low, short longitudinal keel situated subproximally, the proventral one a small cone situated more distally (Figs 10B, 11G-J). Tibia with a low ventral spur carrying a single megaspine plus a long strong ventral bristle more proximally; a series of fine transversal wrinkles subdistally on ventral side (Figs 10B, 11G-J). Band of hooked spinules proventrally on femur II slightly longer than corresponding band on femur I but not reaching distal margin of article, the spinules more widely spaced (Fig. 10B cf. Fig. 10A).

Spines, trichobothria and claws of legs. All femora with numerous long strong bristles dorsally; I: tibia v2; metatarsus v1. II: tibia p2, v1 (megaspine); metatarsus v1. III: patella d1, r1; tibia d2, p2, r2, v4; metatarsus d4, p2, v2. IV: patella d1, r1; tibia d2, p2, r2, v4; metatarsus d5, p1, r1, v3. Trichobothria not counted (difficult to see). Paired tarsal claws with 6-8 teeth on anterior legs, 4-5 on posterior legs; unpaired tarsal claws with 2-3 teeth.

Opisthosoma 1.38 long, 0.95 wide; most hairs abraded, some long dark bristles remaining on anterior margin. PMS 0.26 long, 0.09 wide in the middle, separated from each other by 0.23. PLS 1.28 long (proximal article 0.48 long and 0.18 wide, median article 0.36 long and 0.14 wide, distal article 0.44 long and 0.09 wide in the middle), separated from each other by 0.40.

FEMALE (allotype). Colour in alcohol as in male; no dark colour pattern on opisthosoma discernible.

Body 3.20 long. Carapace 1.38 long, 1.15 wide; thoracic part at same level as cephalic part; only few hairs present (abraded during sieving?), a few stronger ones in front of eye mound and in two paramedian rows behind it; a distinct pit of a single bristle in front of pitlike fovea. Eye group 0.16 long, anterior eye row essentially straight, 0.24 wide, posterior eye row moderately recurved, 0.26 wide. Eye diameters and interdistances: AME 0.03, ALE 0.12, PME 0.08, PLE 0.09; AME-AME 0.03, PME-PME 0.05. MOQ 0.09 long, 0.08 wide anteriorly, 0.17 posteriorly.

Chelicerae stronger than in male, grooves with 13 teeth on promargin. Palpal coxae 0.40 long, 0.26 wide. Labium 0.10 long, 0.29 wide. Sternum 0.79 long, 0.80 wide.
Palps. Total length 2.04 (0.69 + 0.40 + 0.44 + 0.51). No spines, but several long strong bristles dorsally and ventrally on all articles, especially on femur and tibia; tarsus with three strong bristles ventrally. Claws with about 12 teeth.
Legs 32(?)14. Leg I 3.24 long (0.95 + 0.60 + 0.64 + 0.60 + 0.45); leg II missing on both sides; leg III 2.89 long (0.84 + 0.49 + 0.51 + 0.61 + 0.44); leg IV 3.75 long (1.09 + 0.61 + 0.75 + 0.80 + 0.50). Tarsi not pseudosegmented and without spines; without scopuliform hairs. Metatarsal preening combs on legs (II?)III-IV.
Spines, trichobothria and claws of legs. All femora with numerous long strong bristles dorsally; I: metatarsus v2 (plus v2 strong bristles). II: missing. III: patella d2 r1; tibia d3, p2, r2, v4; metatarsus d4, p1, v3. IV: patella d1 r1; tibia d1/2, p2, r2, v5; metatarsus d4/5, p1, v5. Trichobothria not counted (difficult to see). Paired tarsal claws with about 8 teeth on anterior legs and 5 on posterior legs; unpaired tarsal claws with 2-3 teeth.
Opisthosoma 1.40 long, 1.10 wide. PMS 0.25 long, 0.09 wide in the middle, separated from each other by 0.24. PLS 1.29 long (proximal article 0.45 long and 0.16 wide, median article 0.44 long and 0.14 wide, distal article 0.40 long and 0.10 wide in the middle), separated from each other by 0.48.
Vulva with very wide spermathecal trunks; lateral receptacles strongly reduced, boss-like; median receptacles with wide, strongly sclerotised, quite wide and strongly convoluted stalks, these seemingly (to be confirmed when additional females become available) originating on dorsal side of spermathecal trunk (Fig. 11K; in all congeners on ventral or prolateral side).

Variation: The larger one of the two juveniles has two paramedian rows of relatively long bristles between the eye mound and the fovea. The rest of the carapace is only sparsely covered with fine hairs. This is probably the normal hair cover of this species.

Biology: The specimens examined were sieved from the leaf litter of a montane rain forest.

Distribution: *Malayathele cameronensis* sp. nov. is

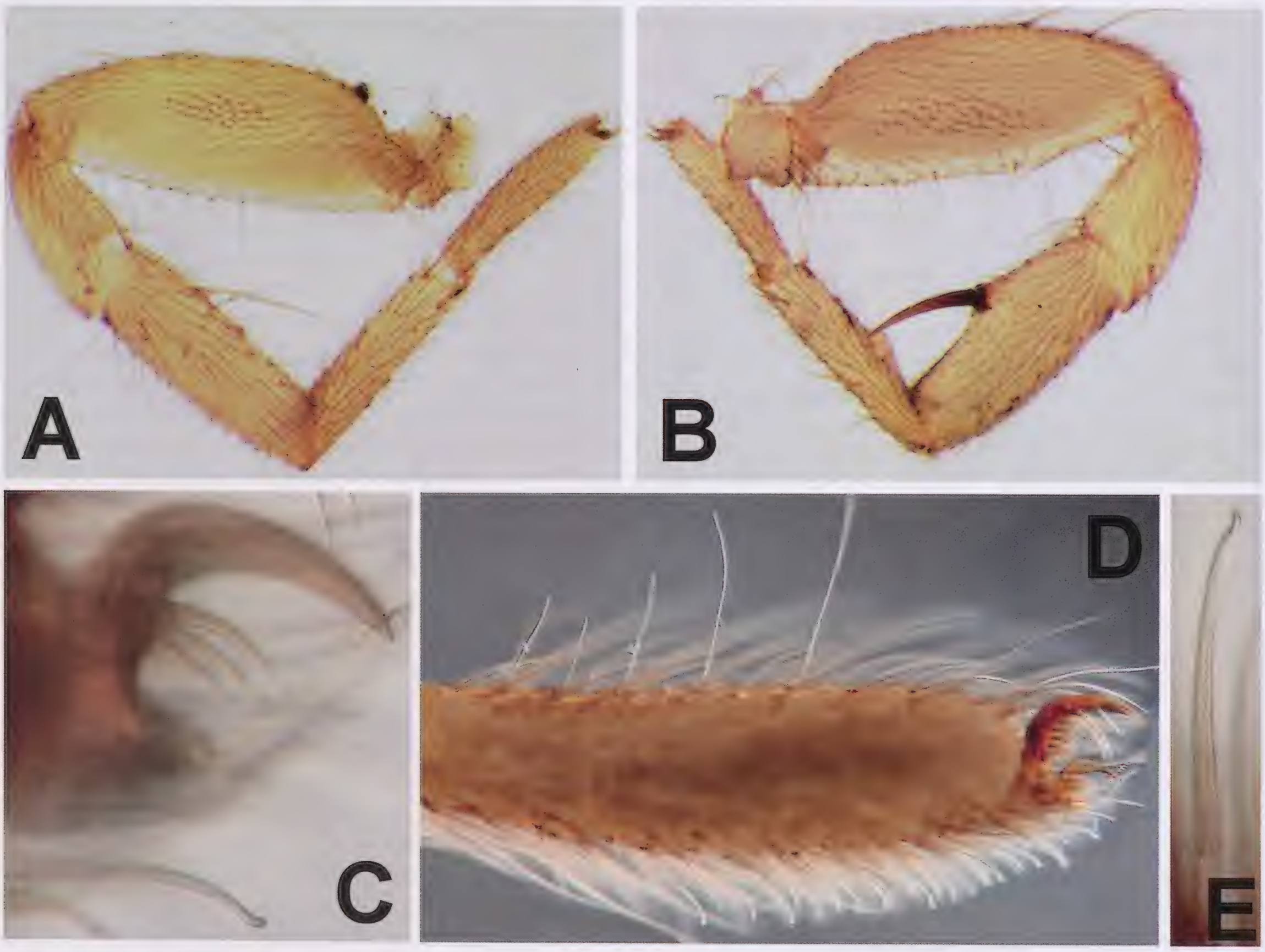


Fig. 10. *Malayathele cameronensis* sp. nov., male holotype. (A) Left leg I, retrolateral view; one ventral spine on tibia fallen off. (B) Left leg II, prolateral view. (C) Unpaired claw and scopuliform hairs of left leg II, prolateral view. (D) Ventrally bulged tarsus of left leg II, prolateral view. (E) Scopuliform hair on left tarsus II. Not to scale.

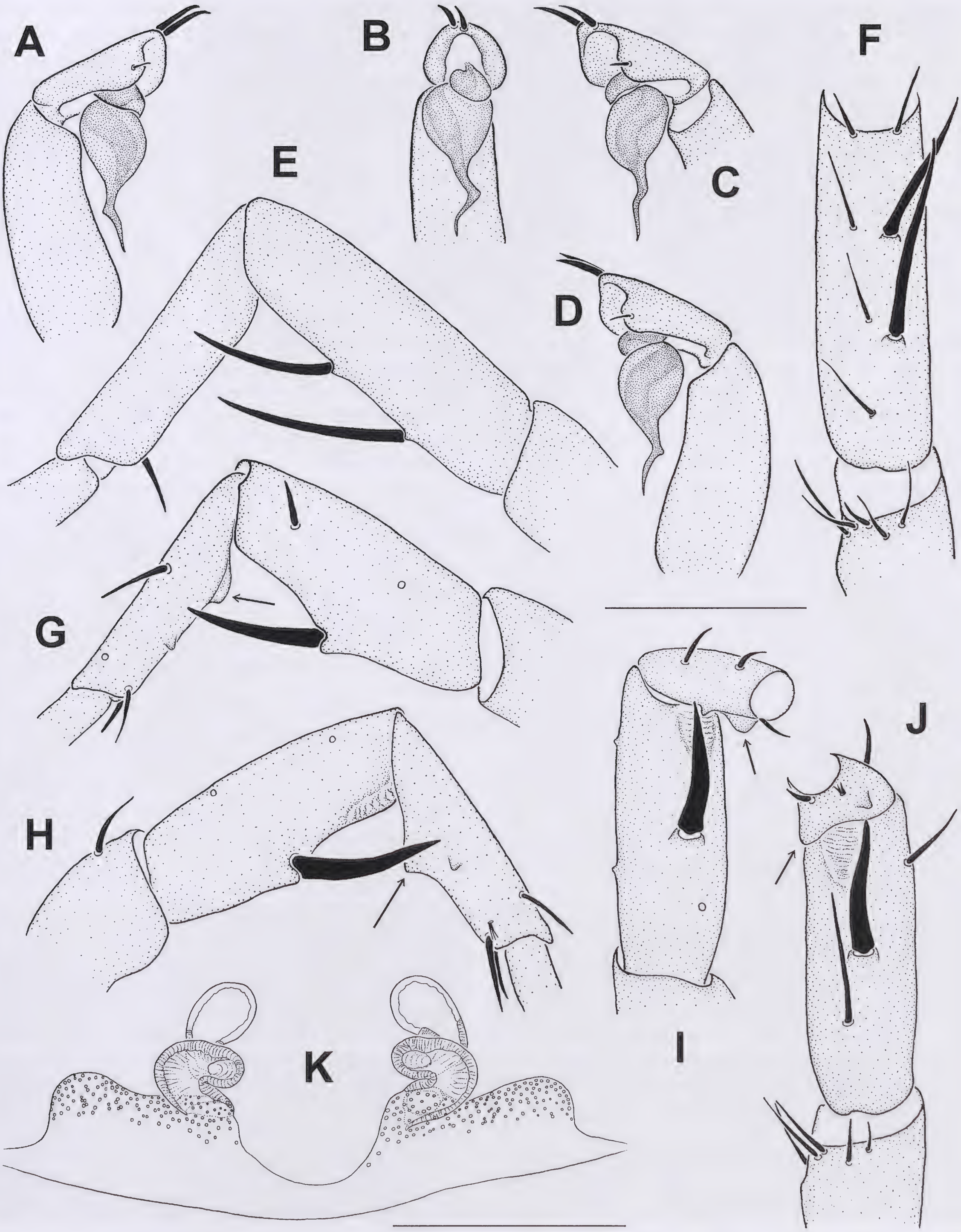


Fig. 11. *Malayathele cameronensis* sp. nov., male holotype (A-J) and female allotype (K). (A) Distal part of left palp, prolateral view. (B) Same, ventral view. (C) Distal part of right palp, proventral and slightly distal view. (D) Same, prolateral view. (E) Patella to metatarsus of right leg I, prolateral view. (F) Patella to tibia of right leg I, ventral view. (G) Patella to metatarsus of right leg II, prolateral view. (H) Same of left leg II, prolateral view. (I) Patella to metatarsus of left leg II, ventral view. (J) Same of right leg II, ventral view. (K) Vulva, dorsal view. Arrows indicate keel-shaped retroventral process on metatarsus II. Scale lines 0.5 mm (A-J), 0.1 mm (K).

known only from the type locality, below the summit of Gunung Jasar in the Cameron Highlands. Surprisingly it occurs only a few kilometres away from localities where *M. ulu* sp. nov. was collected.

Malayathele maculosa Schwendinger, sp. nov.

Figs 12A-D, 13-14

Holotype: MHNG (sample AS-04/12); male; MALAYSIA, Pahang (see comment in paragraph "Distribution"), Fraser's Hill, 1 km south of town, 3°41'N, 101°45'E, 1250 m; 27.VIII.2004; leg. A. Schulz.

Paratypes: MHNG (sample WM93-5); 1 male; Selangor, 1 km below Fraser's Hill, 1280 m; 15.III.1993; leg. I. Löbl & F. Calame. – MHNG (sample AS-04/10); 2 females; Pahang, Fraser's Hill, south side, 3°42'N, 101°45'E, 1300 m; 26.VIII.2004; leg. A. Schulz. – MHNG (sample AS-04/14); 1 male; Pahang, Fraser's Hill, 2 km south of town, 3°41'N, 101°45'E, 1200 m; 28.VIII.2004; leg. A. Schulz. – MHNG (sample AS-04/16); 1 female; Pahang, Fraser's Hill, 2 km south of town, 3°43'N, 101°44'E, 1300 m; 29.VIII.2004; leg. A. Schulz. – MHNG (sample MAL-04/02); 3 females; Pahang, Genting Highlands, Gunung Ulu Kali, below hotel complex, 3°25'42"N, 101°47'41"E, 1650 m, montane rain forest; 18./19.V.2004; leg. P.J. Schwendinger.

Other material: MHNG (sample AS-04/10); 1 juvenile; MALAYSIA, Pahang, Fraser's Hill, south side, 3°42'N, 101°45'E, 1300 m; 26.VIII.2004; leg. A. Schulz. – MHNG (sample AS-04/12); 2 juveniles; Pahang, Fraser's Hill, 1 km south of town, 1250 m; 27.VIII.2004; leg. A. Schulz. – MHNG (sample AS-04/14); 1 juvenile; Pahang, Fraser's Hill, 2 km south of town; 28.VIII.2004; leg. A. Schulz.

Etymology: The Latin adjective "maculosus, -a, -um" (= spotted, mottled) refers to the distinct dark colour pattern on the opisthosoma of females (Fig. 12A-D).

Diagnosis: Males quite similar to those of *M. ulu* sp. nov., distinguished by longer embolus (Fig. 13A-G cf. Fig. 8A-E) and by the presence of two ventral processes on metatarsus II (Fig. 13J-M; proventral one absent in *M. ulu* sp. nov., Fig. 8I-J); distinguished from males of *M. cameronensis* sp. nov. by a curved embolus (Fig. 13A-G; instead of corkscrew-shaped, Fig. 11A-D), by a small conical retroventral process on metatarsus II (Fig. 13J-M; instead of keel-shaped, Fig. 11G-J) and by 5-7 ventral spines on tibia I (Fig. 13H-I; instead of only two, Fig. 11E-F); distinguished from males of *M. kanching* sp. nov. by an only slightly curved embolus (Fig. 13A-G; instead of strongly curved, Fig. 15A-C). Females distinguished from those of all other congeners by a distinct dark colour pattern dorsally and posteroventrally on opisthosoma (Fig. 12A-D; in some *M. kanching* sp. nov. females a faint dorsal pattern confined to dorsal surface); vulva different from that of *M. cameronensis* sp. nov. and *M. kanching* sp. nov. by possessing well developed lateral receptacles with constricted stalks (Fig. 14 cf. Figs 11K, 16), and from that of *M. ulu* sp. nov. by median receptacular stalks shorter and originating more anteriorly (Fig. 14 cf. Fig. 9).

Description: MALE (holotype). Colour in alcohol mostly light brown; palpal organ and cheliceral claws darker; eye mound black; no dark pattern on opisthosoma.

Body 2.73 long. Carapace 1.18 long, 0.90 wide, oval, thoracic and cephalic part at same level; few hairs on carapace (many abraded during sieving), a few stronger hairs in front of eye mound and in two paramedian bands behind it; two long bristles in front of pitlike fovea. Eyes on low mound; eye group 0.14 long, anterior eye row very slightly procurved, 0.20 wide, posterior eye row moderately recurved, 0.23 wide. Eye diameters and interdistances: AME 0.03, ALE 0.09, PME 0.06, PLE 0.07; AME-AME 0.02, PME-PME 0.04. MOQ 0.10 long, 0.09 wide anteriorly, 0.14 posteriorly.

Chelicerae weak, grooves with over 10 teeth on promargin (not all visible). Palpal coxae 0.35 long, 0.23 wide. Labium 0.05 long, 0.19 wide. Sternum 0.69 long, 0.60 wide.

Palps (Fig. 13A-C). Total length 1.59 (0.60 + 0.38 + 0.43 + 0.18). Several long strong bristles dorsally and ventrally on all articles, especially on femur and tibia; tarsus with 2 dorsodistal spines, plus one strong bristle prolaterally-distally and one retrolaterally-distally. Palpal organ with comparatively long, moderately curved embolus.

Legs 3214. Leg I 3.00 long (0.89 + 0.51 + 0.61 + 0.55 + 0.44); leg II 2.78 long (0.83 + 0.50 + 0.53 + 0.51 + 0.41); leg III 2.73 long (0.75 + 0.44 + 0.50 + 0.60 + 0.44); leg IV 3.64 long (0.95 + 0.55 + 0.73 + 0.88 + 0.53). Tarsi not pseudosegmented and without spines; with a few scopuliform hairs in distal portion of anterior legs. Metatarsal preening combs on legs II-IV. Leg I: Tibia carrying 5/6 ventral spines plus one strong ventral bristles subbasally (Fig. 13H-I). Femur with quite short band of hooked spinules retrodorsally. Leg II: Metatarsus with two small conical ventral processes, the proventral one situated at mid-length, the retroventral more proximally (Fig. 13J-K). Tibia with a single megaspine on a low ventral spur and with a long strong ventral bristle more proximally; a series of fine transversal wrinkles subdistally on ventral side (Fig. 13J-L). Band of hooked spinules proventrally on femur II longer than corresponding band on femur I, remote from distal margin of article.

Spines, trichobothria and claws of legs. All femora with numerous long strong bristles dorsally; I: tibia v5/6. II: tibia v1 (megaspine; plus v1 and p2 strong bristles);

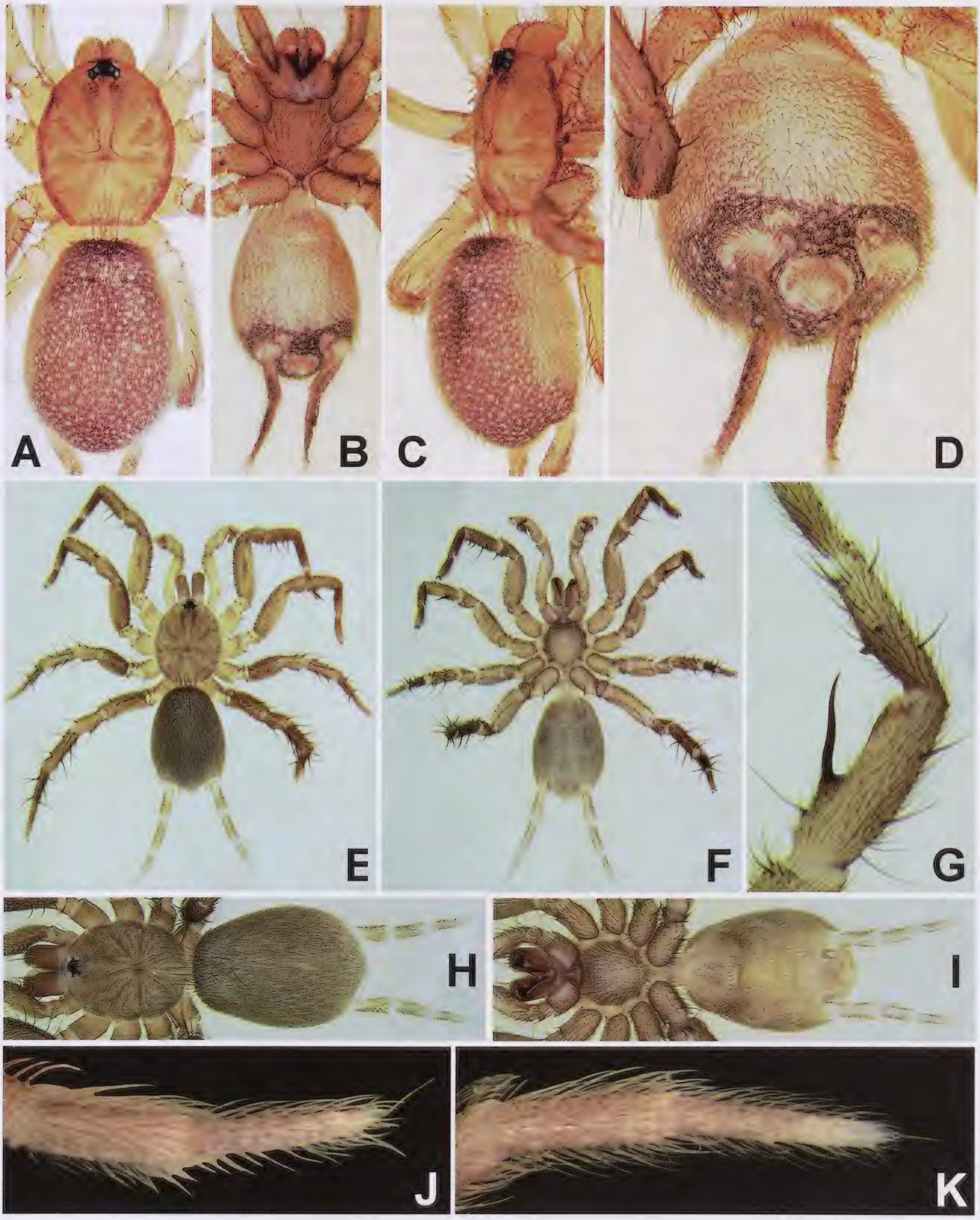


Fig. 12. *Malayathele maculosa* sp. nov., female paratype from Genting Highlands (A-D), *M. kanching* sp. nov., male holotype (E-G), female allotype (H-I) and male paratype (J-K). (A, E, H) Habitus, dorsal view. (B, F, I) Habitus, ventral view. (C) Habitus, dorsolateral view. (D) Opisthosoma, posteroventral view. (G) Tibia and metatarsus of right leg II, prolateral view. (J) Distal part of proximal article and entire median and distal articles of PLS, lateral view. (K) Same, ventral view. Not to scale.

metatarsus v2. III: patella p2, r1; tibia d1, p2, r1, v3 (plus v1 strong bristle); metatarsus d4, p2, v3. IV: patella p1, r1; tibia d1, p2, r2, v5 (plus v1 strong bristle); metatarsus d4, p2, r1, v4. Trichobothria not counted (difficult to see). Paired tarsal claws with 8 teeth on anterior legs, 6-7 on posterior legs; unpaired tarsal claws with 1-3 teeth.

Opisthosoma 1.28 long, 0.81 wide; most hairs on dorsal side abraded, some long dark bristles remaining on anterior margin. PMS 0.20 long, 0.06 wide in the middle, separated from each other by 0.18. PLS 1.11 long (proximal article 0.39 long and 0.14 wide, median article 0.33 long and 0.11 wide, distal article 0.39 long and 0.09 wide in the middle), separated from each other by 0.31.

FEMALE (allotype). Colour in alcohol mostly light brown, with a long, anteriorly widening pair of dark

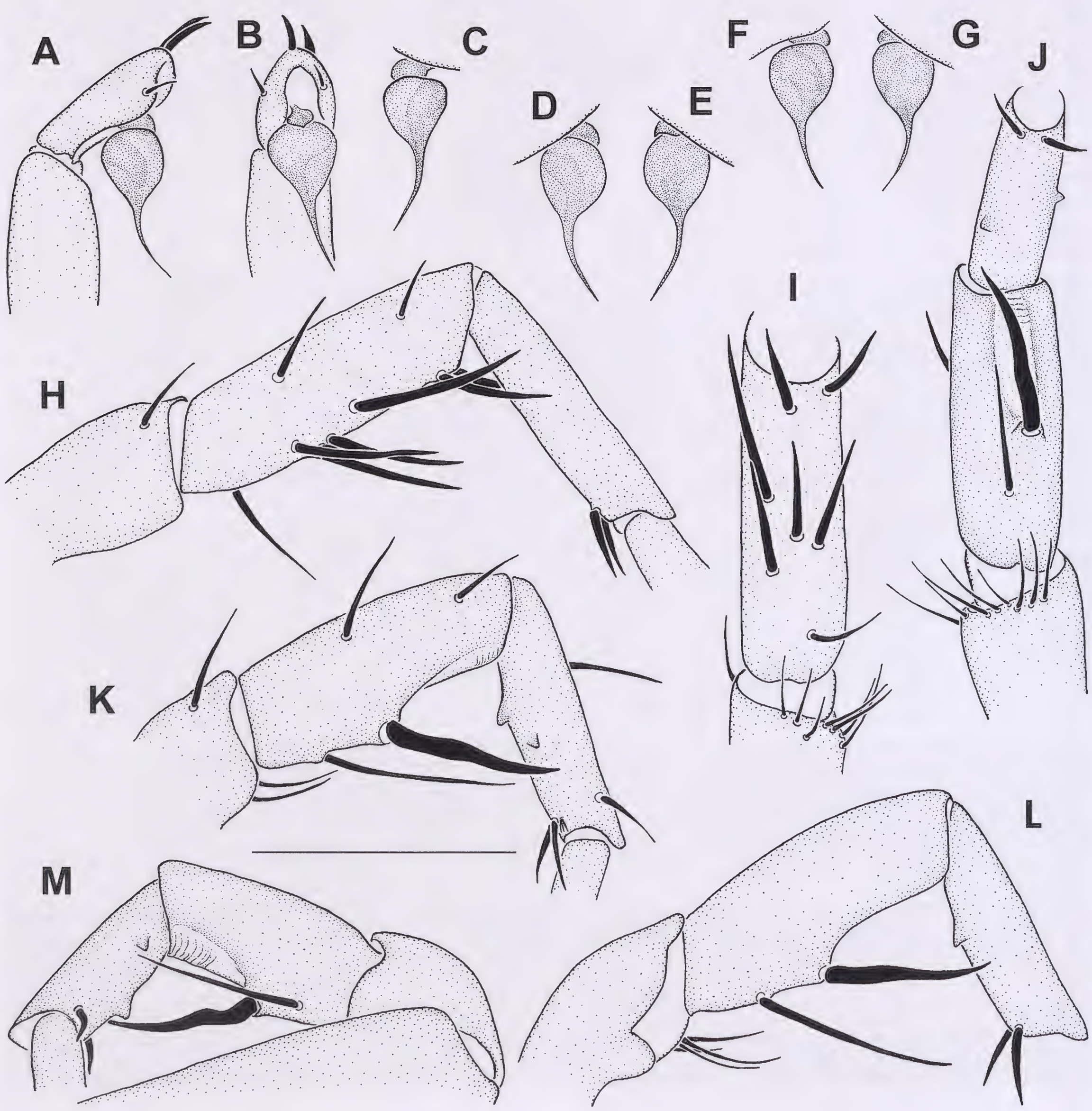


Fig. 13. *Malayathele maculosa* sp. nov., male holotype (A-C, H-L) and two male paratypes (D-E; F-G, M). (A) Distal part of left palp, prolateral view. (B) Same, ventral view. (C, E, G) Palpal organ of right palp, prolateral view. (D, F) Palpal organ of left palp, prolateral view. (H) Patella to metatarsus of left leg I, prolateral view. (I) Patella to tibia of left leg I, ventral view. (J) Patella to metatarsus of right leg II, ventral view. (K) Same of left leg II, prolateral view. (L) Same of right leg II, retrolateral view. (M) Same of left leg II, retrodorsal view. Scale line 0.5 mm.

bands between fovea and eye mound, shorter such paired bands on coxal elevations, and an unpaired band running into posterior margin of carapace (Fig. 12A showing female paratype). Opisthosoma with a dark speckled pattern on entire dorsal side and on posterior quarter of ventral side, leaving light rings around anal tubercle and bases of all spinnerets; lateral sides and anterior three quarters of ventral side cream-coloured (Fig. 12A-D showing female paratype).

Body 4.25 long. Carapace 1.66 long, 1.38 wide; thoracic part level with cephalic part; only few hairs (some abraded?) spread over carapace, a few stronger hairs in front of eye mound and in two paramedian bands behind it; two long bristles anterior of pitlike fovea (Fig. 12A, C showing female paratype). Eye group 0.17 long, anterior eye row very slightly procurved, 0.29 wide, posterior eye row moderately recurved, 0.30 wide. Eye diameters and interdistances: AME 0.05, ALE 0.11, PME 0.07, PLE 0.09; AME-AME 0.04, PME-PME 0.08. MOQ 0.12 long, 0.10 wide anteriorly, 0.19 posteriorly.

Chelicerae stronger than in males, grooves with 14/15 teeth on promargin. Palpal coxae 0.48 long, 0.31 wide. Labium 0.10 long, 0.35 wide. Sternum 0.95 long, 0.88 wide.

Palps. Total length 2.67 (0.84 + 0.55 + 0.63 + 0.65). Several long strong bristles on all articles; 5 weak ventral spines on tibia and 7 weak ventral spines on tarsus. Claws with 11 denticles.

Legs 3214. Leg I 4.17 long (1.20 + 0.74 + 0.89 + 0.79 + 0.55); leg II 3.83 (1.13 + 0.70 + 0.74 + 0.73 + 0.53); leg III 3.73 long (1.04 + 0.61 + 0.71 + 0.86 + 0.51); leg IV 4.97 long (1.38 + 0.78 + 1.00 + 1.15 + 0.66). Tarsi not pseudosegmented and without spines; without scopuliform hairs. Metatarsal preening combs on legs II-IV.

Spines, trichobothria and claws of legs. All femora with numerous long strong bristles dorsally; I: metatarsus v2. II: metatarsus v2. III: patella d1; tibia d2, p2, r1/2, v2/3; metatarsus d4, p2, v3/4. IV: patella d1; tibia d2, p2, r2, v4; metatarsus d4, p2, r1, v4. Trichobothria not counted (difficult to see). Paired tarsal claws with 10-12 teeth on anterior legs and 7-8 on posterior legs; unpaired tarsal claws with 1-3 teeth.

Opisthosoma 1.88 long, 1.28 wide. PMS 0.31 long, 0.10 wide in the middle, separated from each other by 0.40. PLS 1.67 long (proximal article 0.54 long and 0.20 wide, median article 0.50 long and 0.18 wide, distal article 0.63 long and 0.13 wide in the middle), separated from each other by 0.55.

Vulva with anteriorly narrowing spermathecal trunks; lateral receptacles well developed, stalks wide but clearly constricted, heads globular; median receptacles with medium-long, moderately curved stalks with sclerotised walls, originating quite high up on ventral side of spermathecal trunk, heads globular (Fig. 14A).

Variation: Carapace lengths in males (n = 3) range 1.11-1.26, carapace widths 0.84-0.98. The largest female (from the Genting Highlands) has a 1.73 long and 1.45 wide carapace. No noteworthy variation can be seen in the shape of the palpal organs of three males (Fig. 13A-G). There are 5-7 ventral spines on tibia I of males. Distal wrinkles on the ventral side of tibia II are indistinct in all three males examined; few of them are visible in the holotype (Fig. 13J-K), distinctly more in the male from sample AS-04/14 (Fig. 13M). Variation in the shape of the vulvae of three females is shown in

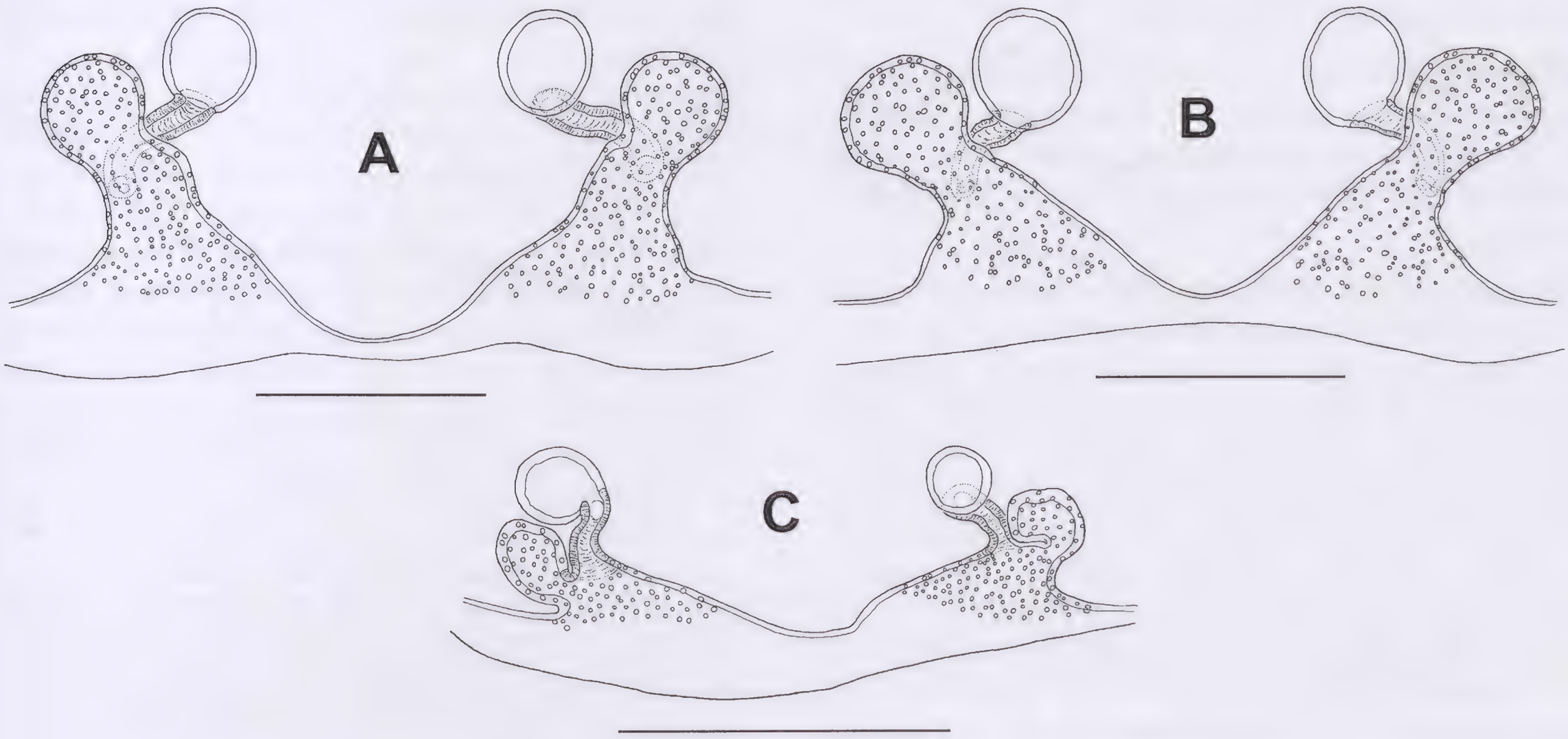


Fig. 14. *Malayathele maculosa* sp. nov., vulvae of three females (all drawn from dissected specimens), dorsal view. (A) Allotype. (B) Paratype from Genting Highlands. (C) Juvenile female paratype from Fraser's Hill. Scale lines 0.1 mm.

Fig. 14. The specimen from sample AS-04/10 is a small female and its vulva appears to be not fully developed (Fig. 14C).

Biology: The specimens examined were sifted from the leaf litter of montane rain forests.

Distribution: *Malayathele maculosa* sp. nov. is known from a few localities between 1200 m and 1300 m on Fraser's Hill, at the border between Pahang and Selangor, and from a locality at 1650 m in the Genting Highlands (Fig. 2, localities 15-16). Although some are given as situated in Pahang State, all localities (including the type locality) on Fraser's Hill probably lie on the Selangor side of the border.

Malayathele kanching Schwendinger, sp. nov.

Figs 1L, 12E-K, 15-16

Holotype: MHNG (sample SIM-01/14); male (matured beginning of XI.2001); MALAYSIA, Selangor, Templer Park (= Hutan Lipur Kanching), above Kanching Waterfall, 3°18'25"N, 101°37'10"E, rain forest, 230-370 m; 13.VII.2001; leg. P.J. Schwendinger.

Paratypes: MHNG; 3 males (matured beginning of VIII.2001, 2.X.2001, beginning of XI.2001) and 7 females (one of them the allotype); collected together with the holotype. – NHMS (sample SIM-01/14); 1 male (matured end of IX.2001) and 1 female; collected together with the holotype. – MHNG (sample F91-1223); 2 females; Selangor, Ulu Gombak, University of Malaya Field Centre, secondary forest along river, 200 m; 26.IX.1991; leg. D. Agosti.

Other material: MHNG and NHMS; 3 juveniles; collected together with the holotype.

Etymology: The species epithet, a name in apposition, refers to the type locality, the Hutan Lipur Kanching. It probably is the old spelling of the Malay word "kancing" = button, usually referring to a hook-like button.

Diagnosis: Males distinguished from those of all other congeners by a strongly curved embolus (Fig. 15A-C), by a single spine retroventrally-distally on patella I (Fig. 15E; in other species a series of bristles at that place), and by a pigmented, triangular area with very indistinct wrinkles retroventrally-distally on tarsus II (Fig. 15F; no pigmented area and more distinct wrinkles in males of other congeneric species); additionally distinct from males of *M. ulu* sp. nov. by the presence of two ventral processes on metatarsus II instead of only a retroventral one (Fig. 15F-H cf. Fig. 8I-J), and from the male holotype of *M. cameronensis* sp. nov. by having numerous ventral spines on metatarsus II instead of only two (Fig. 15D-E cf. Fig. 11E-F). Females distinguished from those of all other congeners by a vulva with wide, ventrad-bent lateral receptacles without constricted stalks (Fig. 16). Some females with a faint dark mottled colour pattern confined to dorsal surface of opisthosoma (some females without such a pattern, Fig. 12H; in females of *M. maculosa* sp. nov. pattern always present and extending to posteroventral area, Fig. 12A-D).

Description: MALE (holotype). Colour in alcohol (Fig. 12E-F, slightly darker in life) mostly light brown; palps, sternum and ventral side of spinnerets slightly lighter; proximal article of chelicerae slightly darker; all membranes and prolateral zone of palpal coxae cream-coloured; cheliceral claw and palpal organ dark brown; eye mound black; carapace with two distinct dark paramedian bands between eye mound and fovea, and with indistinct dark bands on coxal elevations.

Body 3.74 long. Carapace 1.34 long, 1.03 wide, oval, almost flat, thoracic part at same level as cephalic part, quite densely covered with fine, grey, wavy hairs; few stronger bristles in front of eye mound; two long straight bristles in front of pitlike fovea. Eyes on low mound; eye group 0.15 long, anterior eye row slightly procurved, 0.24 wide, posterior eye row moderately recurved, 0.25 wide. Eye diameters and interdistances: AME 0.04, ALE 0.10, PME 0.06, PLE 0.09; AME-AME 0.02, PME-PME 0.06. MOQ 0.12 long, 0.10 wide anteriorly, 0.16 posteriorly.

Chelicerae weak, grooves with 12/13 teeth on promargin and with a short row of tiny medioproximal denticles. Palpal coxae 0.34 long, 0.25 wide. Labium 0.12 long, 0.27 wide. Sternum 0.72 long, 0.71 wide.

Palps (Fig. 15A-B). Total length 1.87 (0.64 + 0.42 + 0.46 + 0.35). Several long strong bristles dorsally and ventrally on all articles, especially on femur and tibia; tarsus with 2 spines distally and with a strong bristle prolaterally-distally as well as retrolaterally-distally. Palpal organ with hook-shaped embolus, its apex strongly curved ventrad.

Legs 2314. Leg I 3.49 long (0.99 + 0.62 + 0.68 + 0.67 + 0.53); leg II 3.19 long (0.89 + 0.55 + 0.61 + 0.62 + 0.52); leg III 3.36 long (0.87 + 0.48 + 0.72 + 0.74 + 0.55); leg IV 4.16 long (1.08 + 0.60 + 0.82 + 0.99 + 0.67). Tarsi not pseudosegmented and without spines; with a few scopuliform hairs in distal portion of anterior legs. Metatarsal preening combs on legs II-IV (missing on right leg II). Leg I: Tibia carrying 6 ventral spines (Fig. 15D-E). Patella with a single, slightly curved retroventral-distal spine (Fig. 15E). Distal part of femur with short band of hooked spinules retrodorsally. Leg II: Metatarsus with two small conical processes, the proventral one slightly smaller and situated more distal than the retroventral one (Fig. 15F-G). Tibia ventrally with a low median spur carrying a single megaspine and with a long strong bristle situated more proximally; a pigmented triangular area with indistinct wrinkles retroventrally-distally (Fig. 15F). Band of hooked spinules proventrally on femur II slightly longer than corresponding retrodorsal band on femur I, remote from

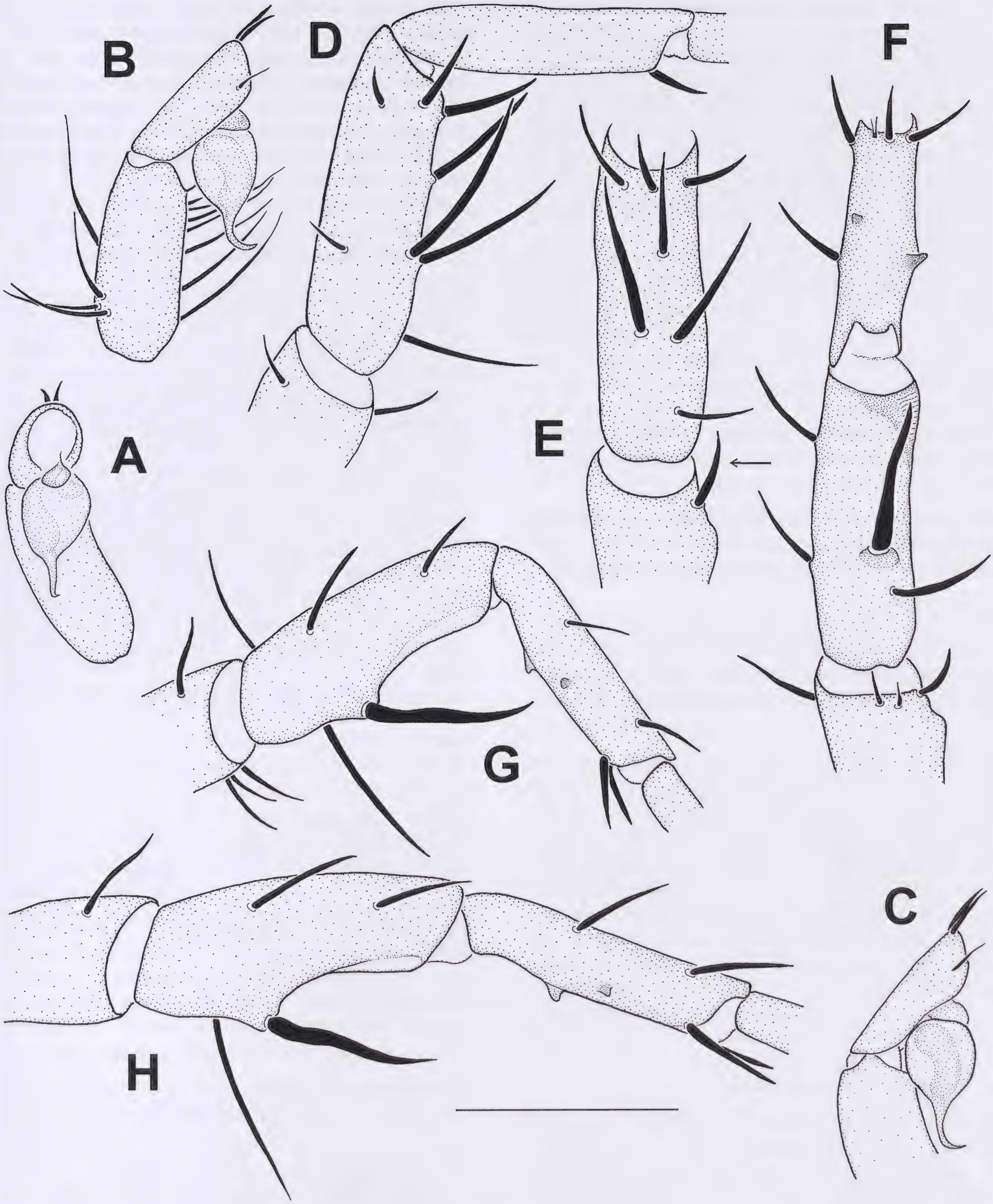


Fig. 15. *Malayathele kanching* sp. nov.; male holotype (A-B, D-G) and male paratype (C, H). (A) Distal part of right palp, ventral view. (B-C) Same of left palp, prolateral view. (D) Patella to metatarsus of left leg I, prolateral view. (E) Patella and tibia of left leg I, ventral view. (F) Patella to metatarsus of left leg II, ventral view. (G-H) Same, prolateral view. Arrow indicates single spine retroventrally-distally on patella I. Scale line 0.5 mm.

distal margin of article, spinules more widely spaced.
Spines, trichobothria and claws of legs. All femora with numerous long strong bristles dorsally; I: patella v1; tibia p2, v6; metatarsus v1. II: patella v1; tibia p2, v1 (megaspine); metatarsus p2, v2. III: patella d4; tibia d3, p2, r2, v5; metatarsus d5, v5. IV: patella d3; tibia d3, p2, r2, v6; metatarsus d6, v5. Trichobothria not counted (difficult to see). Paired tarsal claws with 8-9 teeth on anterior legs, 5-6 on posterior legs; unpaired claws with 2-3 teeth.
Opisthosoma 1.76 long, 1.19 wide; densely covered with fine adpressed grey hairs interspersed with longer dark bristles (longest on anterior margin; Fig. 12E-F). PMS 0.22 long, 0.07 wide in the middle, separated from each other by 0.37. PLS 1.63 long (proximal article 0.56 long and 0.15 wide, median article 0.55 long and 0.12 wide, distal article 0.52 long and 0.09 wide in the middle), separated from each other by 0.60; distal article not pseudosegmented, weakly pigmented in distal half (Fig. 12J-K showing male paratype).

FEMALE (allotype). Colour in alcohol as in male, but all dark bands on carapace indistinct, no dark colour pattern on dorsal side of opisthosoma discernible (Fig. 12H-I).
Body 5.20 long. Carapace 1.85 long, 1.53 wide. Eye group 0.19 long, anterior eye row slightly procurved, 0.29 wide, posterior eye row slightly recurved, 0.32 wide. Eye diameters and interdistances: AME 0.05, ALE 0.12, PME 0.08, PLE 0.09; AME-AME 0.04, PME-PME 0.06. MOQ 0.14 long, 0.12 wide anteriorly, 0.20 posteriorly.
Chelicerae stronger than in males, grooves with 15 teeth on promargin and with a short row of about 10 tiny medioproximal denticles. Palpal coxae 0.50 long, 0.36 wide; serrula composed of a band of tiny denticles (Fig. 1L showing female paratype). Labium 0.13 long, 0.43 wide. Sternum 0.98 long, 0.96 wide.
Palps. Total length 2.74 (0.90 + 0.56 + 0.63 + 0.65). Several long strong bristles dorsally and ventrally on all articles, especially on femur and tibia; tarsus with 4 distinct ventral spines. Claw with 10 teeth.
Legs 3214. Leg I 4.20 long (1.23 + 0.76 + 0.85 + 0.78 + 0.58); leg II 3.96 long (1.23 + 0.71 + 0.71 + 0.71 + 0.60); leg III 3.91 long (1.05 + 0.65 + 0.73 + 0.85 + 0.63); leg IV 4.97 long (1.28 + 0.90 + 1.00 + 1.10 + 0.69). Tarsi not pseudosegmented and without spines; without scopuliform hairs. Metatarsal preening combs on legs II-IV.
Spines, trichobothria and claws of legs. All femora with numerous long strong bristles dorsally; I: patella p2; tibia p2 (weak), v5; metatarsus v4/5. II: patella p2; tibia p2 (weak), v4; metatarsus p2, v5. III: patella d3; tibia d4, p2, v5; metatarsus d5, v5/6. IV: patella d2; tibia d6, p2, v5; metatarsus d6, v5/6. Trichobothria not counted (difficult to see). Paired tarsal claws with 9-11 teeth on anterior legs, 7-8 on posterior legs; unpaired tarsal claws with 2-3 teeth.
Opisthosoma 2.65 long, 1.88 wide. PMS 0.30 long, 0.10

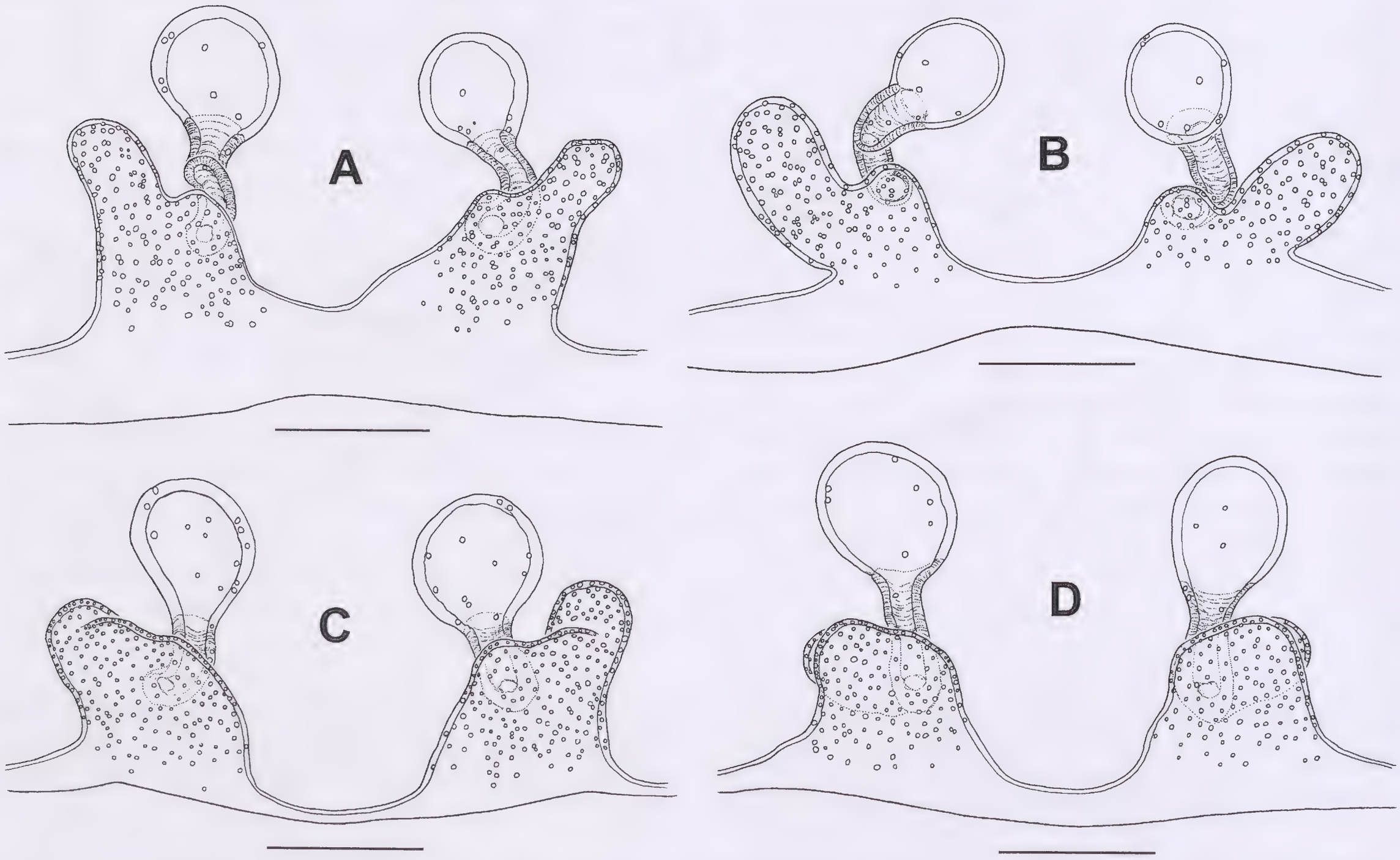


Fig. 16. *Malayathele kanching* sp. nov.; vulvae of four female paratypes, dorsal (A-B) to increasingly more postero-dorsal view (C-D). (A, C-D) Specimens from the Templer Park. (B) Specimen from Ulu Gombak. Scale lines 0.05 mm.

wide in the middle, separated from each other by 0.58. PLS 1.91 long (proximal article 0.68 long and 0.23 wide, median article 0.59 long and 0.19 wide, distal article 0.64 long and 0.14 wide in the middle), separated from each other by 0.88.

Spermathecae (of female paratypes, allotype not dissected; Fig. 16) wide, somewhat trapezoidal in shape; lateral receptacles without constricted stalks, therefore transition to spermathecae not well marked, apex bent ventrad; median receptacle with medium-long and medium-thin curved stalks with sclerotised walls.

Variation: Carapace lengths in males (n = 5) range 1.28-1.44, carapace widths 1.03-1.19. The largest female (from Templer Park) has a 1.87 long and 1.50 wide carapace. For variation in the shape of the vulvae see Fig. 16. The lateral receptacles are bent ventrad and therefore the vulvae look quite different when seen from different angles. The stalks of the median receptacles are more or less strongly curved or twisted. Variation in the shape of palpal organs and of tibiae and metatarsi II is shown in Fig. 15. All males possess a single retroventral-distal spine on patella I. There are 6-7 ventral spines on tibia I of males (seven spines only in two males and only on one side of the body). In all males, eleven females (including the allotype, Fig. 12H) and two juveniles from the type locality no dark dorsal pattern on the opisthosoma is discernible. In three females and one juvenile (all with most opisthosomal hairs abraded) a very indistinct one can be seen. In two females from Ulu Gombak (also with most hairs abraded) a dark mottled dorsal pattern is clearly visible, but it is less pronounced than in females of *M. maculosa* sp. nov. and it does not extend to the posteroventral area. Thus the opisthosomal colour pattern appears to be usually present in these two species, but it is hidden under the hair cover.

Relationships: Geographical proximity (in horizontal, not vertical respect), similarities in male and female copulatory organs and the common presence of a more or less pronounced dark pattern on the opisthosoma of females indicate a close relationship between *M. kanching* sp. nov. and *M. maculosa* sp. nov.

Distribution: This species is known from two lowland localities (Templer Park and Ulu Gombak) near Kuala Lumpur (Fig. 2, localities 17-18).

Biology: The specimens examined were collected by sieving leaf litter in rain forests. The Templer Park site is near a small stream and a waterfall. Some spiders from there were kept in captivity in Geneva where they mated and reproduced. Five males (collected in mid-July) matured between the beginning of August and the beginning of November of the same year, which probably corresponds to the mating period in nature.

Other related species

Numerous additional female and juvenile specimens with a euagrid/diplurid habitus, collected in Southeast Asia by sieving leaf litter and by soil extractions by means of Berlese funnels, are lodged in the MHNG. Mature male specimens are necessary for a proper generic placement (and in the case of the first species for a proper identification). These unidentified specimens do not seem to belong to *Phyxioschema* or *Masteria,* the latter of which has not yet been found on mainland SE-Asian or the Sunda Islands. They can be assigned to at least four species, three of them presumably unnamed.

Malayathele sp.

Material: MHNG; 2 juveniles; MALAYSIA, Perak, NE of Chenderiang, 300 m, rain forest; 22.-31.I.1994; leg. P.J. Schwendinger.

Remark: The locality (Fig. 2, locality 13) lies about 20 km south of Ulu Groh, the type locality of *M. ulu* sp. nov., and these specimens are presumably conspecific.

Malayathele sp.

Material: MHNG; 1 female; MALAYSIA, Kelantan, Jeram Pasu Waterfall, 100 m, rain forest; 10./11.I.1999; leg. P.J. Schwendinger.

Remarks: The locality (Fig. 2, locality 19) of this specimen is quite distant from the localities of the species described above. The spider is a fully adult female which possesses metatarsal preening combs and a relatively thin hair cover on the carapace, and therefore most likely belongs to the genus *Malayathele* gen. nov. Its vulva (not illustrated) resembles that of the *M. cameronensis* sp. nov. female in having reduced lateral receptacles; it is distinguished by narrow spermathecal trunks and by the lateral receptacles essentially lost.

?Malayathele sp.

Material: MHNG; 1 female (sample Sum-06/31); INDONESIA, North Sumatra Province, Lumban Rang National Park, near road from Prapat to Porsea, 2°36'14"N, 99°02'42"E, 1350 m, rain forest; 1.VII.2006; leg. P.J. Schwendinger.

Remarks: This specimen resembles *Malayathele* specimens from Peninsular Malaysia in having metatarsal preening combs and a quite thin hair cover on the carapace. Due to the lack of cuspules and to the shape of the palpal coxae (with bulging ventral surface, pale and glabrous prolateral zone and without retrolateral-proximal heel) and of the labium (with pale

and glabrous anterior zone) it clearly is not an early instar of a *Macrothele* (Macrothelidae), a spider genus that also occurs on Sumatra and has a similar habitus. The specimen appears to be a female, but its genital region was not dissected. The locality (not given in Fig. 2) is far away from the localities of the species treated above, separated by the Straits of Malacca, and therefore it is possible that this specimen belongs to an undescribed genus. The MHNG houses extensive spider material collected by extraction of forest litter on Sumatra, but this is the only euagrid/diplurid specimen among them.

Euagridae/Dipluridae gen. sp.

Material: MHNG; 1 juvenile female (sample Sar-87/90); SINGAPORE, jungle part of Botanical Garden, 25 m; 16.XII.1987; leg. B. Hauser. – MHNG; 18 juveniles (sample SL/SI-93/2); SINGAPORE, NW corner of Sentosa Island, rain forest remnant, 30 m; 21.VII.1993; leg. B. Hauser. – MHNG; 6 juveniles (sample SBH-96/3); SINGAPORE, SE part of Bukit Timah Nature Reserve, Rifle Range Road, rain forest; 20.XI.1996; leg. B. Hauser. – MHNG; 10 juveniles (sample SBH-96/4); SINGAPORE, NNW of MacRitchie Reservoir, "Campnospermum Track", 40 m, rain forest remnant; 21.XI.1996; leg. B. Hauser. – MHNG; 1 juvenile (sample SBH-96/5); SINGAPORE, NNW of MacRitchie Reservoir, 60 m, rain forest; 21.XI.1996; leg. B. Hauser. – MHNG; 1 juvenile (sample SIM-01/06); INDONESIA, Bintan Island, about 5 km NW of Kijang, Mt Langkuas, 0°52'34"S, 104°34'45"E, 125-220 m, disturbed rain forest; 22./23. VI.2001; leg. P.J. Schwendinger. – MHNG; 3 juveniles (sample SIM-01/04); INDONESIA, Singkep Island, Batu Ampar Waterfall, about 10 km NW of Dabo, 0°29'31"S, 104°28'31"E, 80 m, rain forest; 17./18. VI.2001; leg. P.J. Schwendinger.

Remarks: All available specimens are distinctly smaller than the adult *Malayathele* gen. nov. specimens examined. The largest specimen (from Singapore; Fig. 2, locality 20) has a vulva with fully developed lateral receptacles, which resembles that of *M. kanching* sp. nov. females. However, the absence of metatarsal preening combs and the presence of only two eyes (seemingly the AME) indicate that this represents an undescribed genus. The spider fauna of Singapore Island is quite well documented, but to our knowledge no such spiders have ever been reported from there. It is possible that they were actually collected, but ignored or discarded as juveniles. Obviously this species is obscure, but nevertheless widely distributed on Singapore and the Indonesian islands south of it. Singkep Island is over 200 km away from Singapore.

DISCUSSION

Taxonomy: Within the species treated in this paper, two clearly defined groups can be recognized. The absence of metatarsal preening combs, the presence of two or more megaspines and of a transversal subdistal ridge on the ventral side on tibia II clearly distinguishes *L. bencha* and *L. chang* sp. nov. in southern Thailand from the four species in Malaysia. The latter lack metatarsal preening combs, and the ventral side of tibia II has only a single megaspine and no subdistal ridge. Females of the Thai species (*Leptothele* spp.) have non-sclerotised median receptacular stalks, the Malaysian species have those stalks sclerotized. These very obvious morphological differences justify the separation of these two species groups into different genera, and thus *Malayathele* gen. nov. is established to harbour the four new Malaysian species.

Within those, *M. kanching* sp. nov. and *M. cameronensis* sp. nov. stand out by displaying modifications of the embolus (hook-shaped and corkscrew-shaped, respectively) not seen in other Asian Euagridae. In *Leptothele* spp. and *Phyxioschema* spp. the embolus is quite straight and/or only slightly curved at the apex (Schwendinger, 2009; Schwendinger & Zonstein, 2011; Schwendinger & Zamani, 2018). Moreover, these two exceptional species possess modifications of the lateral receptacles (bent ventrad and stalk not constricted in *M. kanching* sp. nov.; reduced to a boss in *M. cameronensis* sp. nov.) that are also unique within the Asian Euagridae. The unnamed *Malayathele* sp. at the Jeram Pasu Waterfall (Fig. 2, locality 19), so far only known from a single female, is equally remarkable: it has completely reduced lateral receptacles (not illustrated). Without a phylogeny and more species (undoubtedly additional ones will be discovered in the future) it is premature to draw conclusions on relationships, but we believe that dwarfism and a trend for modifications of the embolus and of the lateral receptacles is a strong indication that *Malayathele* spp. are more derived than the species in *Leptothele* and *Phyxioschema*.

Biogeography: The newly available material shows that Euagridae (and possibly Dipluridae) are fairly species-rich and widely distributed on the Thai-Malay Peninsula, Sumatra, Singapore and nearby islands. *Leptothele bencha* is widespread and actually fairly common along the Andaman coast of southern Thailand (south of Phangnga), but due to its small size and obscure habitat (leaf litter) has so far been largely overlooked. This lack of previous records is particularly surprising for the generally well-investigated spider fauna of Singapore. Further collecting by means of sieving or Berlese-extraction of forest litter in that area will undoubtedly uncover a much greater diversity in species and genera, and probably also a much wider geographical range.

ACKNOWLEDGEMENTS

We thank John Hollier (MHNG) for checking the English text, and Bernd Hauser (Geneva, Switzerland), Ivan Löbl (Veyrier, Switzerland), Donat Agosti (Bern, Switzerland), Andreas Schulz (Leverkusen, Germany) and Petr Banar (Moravian Museum, Brno, Czech Republic) for providing specimens. Hans Bänziger (Chiang Mai University, Thailand) took one of us (PJS) to Ulu Groh, Chenderiang and many other places in Malaysia and Thailand. Sergei Zonstein (Tel-Aviv University, Israel) kindly reviewed the manuscript and helped to improve it. The Royal Forest Department of Thailand allowed collecting in protected areas.

REFERENCES

Ausserer A. 1875. Zweiter Beitrag zur Kenntniss der Arachniden-Familie der Territelariae Thorell (Mygalidae Autor). *Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien* 25: 125-206.

Coyle F.A. 1986. Courtship, mating, and the function of male-specific leg structures in the mygalomorph spider genus *Euagrus* (Araneae, Dipluridae) [pp. 33-38]. *In*: Eberhard E.G., Lubin Y.D., Robinson B.C. (eds). Proceedings of the 9th International Congress of Arachnology, Panama 1983. *Smithsonian Institution Press, Washington,* 333 pp.

Coyle F.A. 1988. A revision of the American funnel-web mygalomorph spider genus *Euagrus* (Araneae, Dipluridae). *Bulletin of the American Museum of Natural History* 187: 203-292.

Opatova V., Hamilton C.A., Hedin M., Montes de Oca L., Král J., Bond J.E. 2020. Phylogenetic systematics and evolution of the spider infraorder Mygalomorphae using genomic scale data. *Systematic Biology* 69(4): 671-707.

Passanha V., Brescovit A.D. 2018. On the Neotropical spider subfamily Masteriinae (Araneae, Dipluridae). *Zootaxa* 4463(1): 1-73.

Raven R.J. 1979. Systematics of the mygalomorph spider genus *Masteria* (Masteriinae: Dipluridae: Arachnida). *Australian Journal of Zoology* 27: 623-636.

Raven R.J. 1981a. The mygalomorph spider genera *Phyxioschema* Simon and *Stenygrocerus* Simon (Dipluridae: Ischnothelinae). *Bulletin of the British Arachnological Society* 5(5): 225-231.

Raven R.J. 1981b. Three new mygalomorph spiders (Dipluridae, Masteriinae) from Colombia. *Bulletin of the American Museum of Natural History* 170: 57-63.

Raven R.J. 1985. The spider infraorder Mygalomorphae (Araneae): cladistics and systematics. *Bulletin of the American Museum of Natural History* 182(1): 1-180.

Raven R.J., Schwendinger P.J. 1989. On a new *Phyxioschema* (Araneae, Mygalomorphae) from Thailand and its biology. *Bulletin of the British Arachnological Society* 8(2): 55-60.

Raven R.J., Schwendinger P.J. 1995. Three new mygalomorph spider genera from Thailand and China (Araneae). *Memoirs of the Queensland Museum* 38(2): 623-641.

Schwendinger P.J. 2009. A taxonomic revision of the genus *Phyxioschema* (Araneae, Dipluridae), I: species from Thailand. *Zootaxa* 2126: 1-40.

Schwendinger P.J., Ono H. 2011. On two *Heptathela* species from southern Vietnam, with a discussion of copulatory organs and systematics of the Liphistiidae (Araneae; Mesothelae). *Revue suisse de Zoologie* 118(4): 599-637.

Schwendinger P.J., Zamani A. 2018. A new species of *Phyxioschema* (Araneae: Dipluridae) from Iran. *Revue suisse de Zoologie* 125(2): 283-289.

Schwendinger P.J., Zonstein S.L. 2011. A taxonomic revision of the genus *Phyxioschema* (Araneae, Dipluridae), II: species from Central Asia. *Zootaxa* 2815: 28-48.

Simon E. 1889. Voyage de M.E. Simon au Venezuela (Décembre 1887 - Avril 1888), 4e mémoire, Arachnides. *Annales de la Société Entomologique de France* (sér. 6) 9: 169-220, pls 1-3.

Simon E. 1892. Voyage de M. E. Simon aux îles Phillipines (mars et avril 1890), 4e mémoire, Arachnides. *Annales de la Société Entomologique de France* 61: 35-52, pl. 2.

World Spider Catalog 2020. World Spider Catalog. Version 21.5. Natural History Museum Bern. Available at http://wsc.nmbe.ch (accessed in August 2020).

REVUE SUISSE DE ZOOLOGIE
Swiss Journal of Zoology

Instructions to Authors

The *Revue suisse de Zoologie* publishes original research results of zoological systematics and related fields. All manuscripts will be refereed by taxonomic experts.

Submission of a manuscript implies that it has been approved by all authors, that it reports their unpublished work and that it is not being considered for publication elsewhere.

The language must be English, exceptionally and in well-founded cases French, German, or Italian are possible.

There is no maximal length of the articles, but manuscripts longer than 50 pages should be discussed first with the editors.

A financial contribution may be asked from the authors if the number of colour illustrations exceeds a certain number.

Manuscripts must be submitted via email (rsz.mhn@ville-ge.ch) as an attached Microsoft Word (.doc or .docx) or Rich Text file (.rtf).

For more details on how to prepare your manuscript, please consult the PDF document "RSZ Instructions to Authors" available on our web page or contact us per email.

Revue suisse de Zoologie
Muséum d'histoire naturelle
CP 6434
CH-1211 Genève 6
Switzerland.

E-mail: rsz.mhn@ville-ge.ch

SMITHSONIAN LIBRARIES
3 9088 01972 0259

REVUE SUISSE DE ZOOLOGIE
Swiss Journal of Zoology

VOLUME
127 (2) – 2020

Li W., Qi L. & Yang D. - First Chinese record and the second species of the genus *Pleurigona* Malloch, 1929 (Diptera: Lauxaniidae) 245-248

Gilgado J.D. - Hidden in plain sight: six millipede species (Myriapoda: Diplopoda) new for the fauna of Switzerland 249-259

Draghi R., Drago F.B., Saibene P.E. & Agostini M.G. - Helminth communities from amphibians inhabiting agroecosystems in the Pampean Region (Argentina) 261-274

Logunov D.V. & Ponomarev A. - *Karakumosa* gen. nov., a new Central Asian genus of fossorial wolf spiders (Araneae: Lycosidae: Lycosinae) 275-313

Sartori M. & Bauernfeind E. - Mayfly types and additional material (Insecta: Ephemeroptera) examined by F.-J. Pictet and A.-E. Pictet, housed in the Museums of Natural History of Geneva and Vienna 315-339

Hollier J., Marshall J. & Legendre F. - An annotated list of the Blattodea (Insecta) described by Henri de Saussure. Part 1: the Corydiidae 341-348

Tanasevitch A.V. - Linyphiid spiders collected by V. Mahnert in Kenya, with the description of a new genus and two new species (Arachnida: Araneae) 349-360

Yin Z.-W. & He L. - A new species of *Diartiger* Sharp from Sichuan, China (Coleoptera: Staphylinidae Pselaphinae) 361-366

Galea H.R. - *Plumularia roxanae,* a new epiphytic hydroid (Cnidaria: Hydrozoa:Plumulariidae) from the Indo-Pacific 367-376

Yin Z.-W. & Kleeberg A. - Description of *Cerochusa gesinae* sp. nov. from Thailand (Coleoptera: Staphylinidae: Pselaphinae) 377-380

Martens J. - A mysterious dwarf: Suthepiidae nov. fam., a new harvestman family from mountains of northern Thailand (Arachnida: Opiliones: Laniatores) 381-391

Lorenzo D., Ricarte A., Nedeljković Z., Nieves-Aldrey J.L. & Marcos-García M.A. - Hoverflies (Diptera: Syrphidae) of E Ventorrillo Biological Station, Madrid province, Spain: a perspective from a late twentieth century inventory 393-412

Janssen H.Y., Jin-Long R., Jia-Tang L., Zeng W., Nguyen T.T., Nguyen T.Q., Bui Q.T.T., Ngo H.T., Le M.D. & Ziegler T. - Range extension and extended diagnosis of *Lycodon pictus*: First country record from China 413-422

Schwendinger P.J., Lehmann-Graber C., Hongpadharakiree K. & Syuhadah N. - New euagrid spider species fom Thailand and Malaysia, and new localities of *Leptothele bencha* (Arachnida: Araneae) 423-453

Indexed in Current Contents. Science Citation Index

Muséum genève

Swiss Zoological Society

VILLE DE GENÈVE